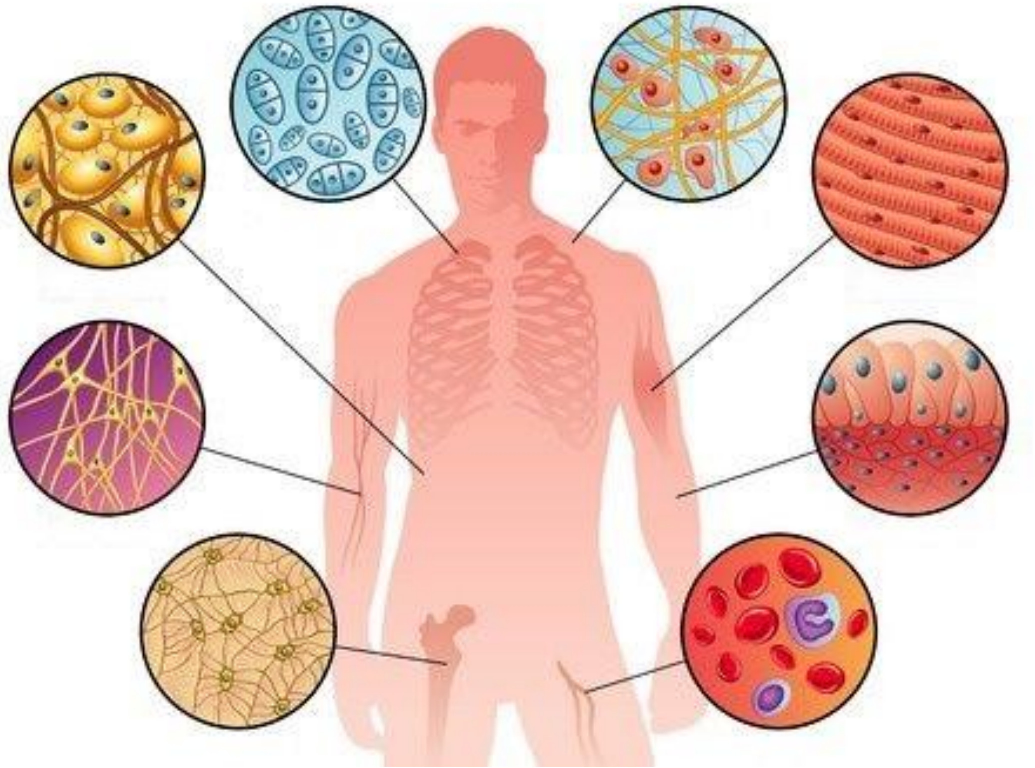
Animal Tissue



TISSUES

Epithelial Tissues
(a.k.a. *Covering tissues*. These tissues are present for **protection**.)

Connective Tissues
(a.k.a. *Supporting tissues*. These tissues help in **binding** different body structures.)

Muscular Tissues
(a.k.a. *Contractile tissues*. These tissues help in **movements** and **locomotion**.)

Nervous Tissues
(a.k.a. *Conducting tissues*. These tissues help in conduction of **nerve impulses**.)

EPITHELIAL TISSUE

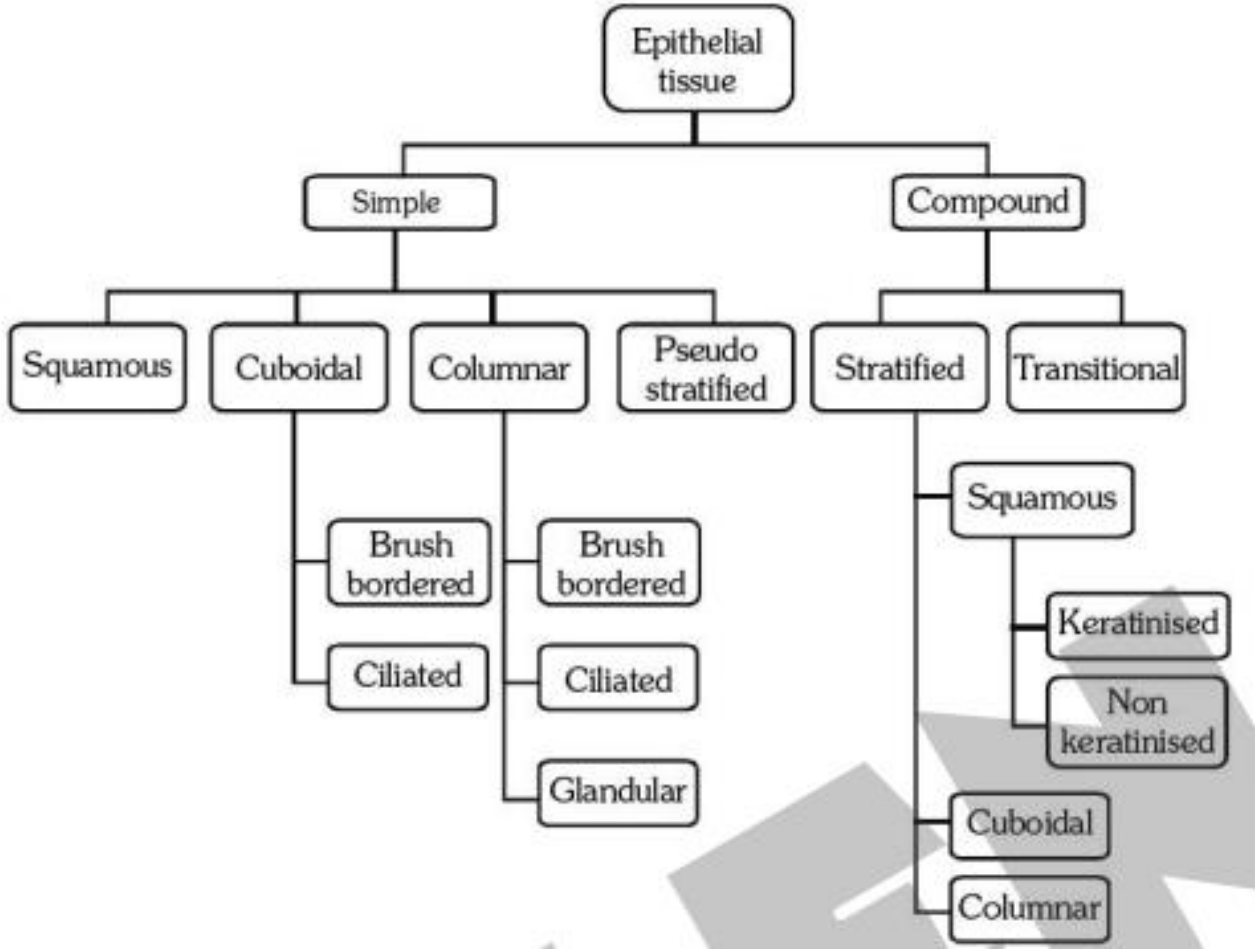
General position:

-It covers the outer and inner surface of all the organs of the body and also lines the cavities of all the hollow organs of the body.

Structure:

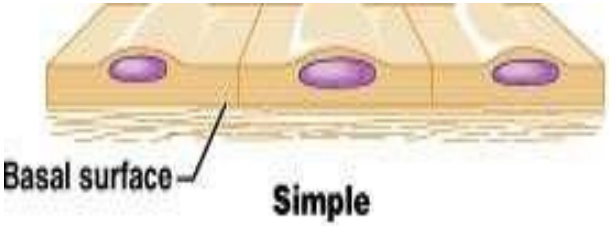
- Cells are arranged in one or more layers.
- Cells are **compactly arranged** and there is **no or very little intercellular material (matrix)** between them.
- Cells of the lowermost layer rest on thin, double layered, non-cellular, non-living **basement membrane** (or **basal lamina**)
- Cells may originate from any primary germ layer i.e. **ectoderm** (e.g. epidermis of skin), **mesoderm** (e.g. coelomic i.e body cavity epithelium), **endoderm** (e.g. mid-gut epithelium).
- Cells are **non-vascular** or **avascular**, i.e. they lack their own blood supply. These cells get their nutrition from the blood capillaries present in the underlying connective tissue.
- Cells have the power of **division and regeneration** throughout life. The old injured dead cells are **sloughed** off (removed) regularly.
- **Free surface** of the cells may be smooth or may have fine hair-like cilia or microvilli.

Types of Epithelial Tissue



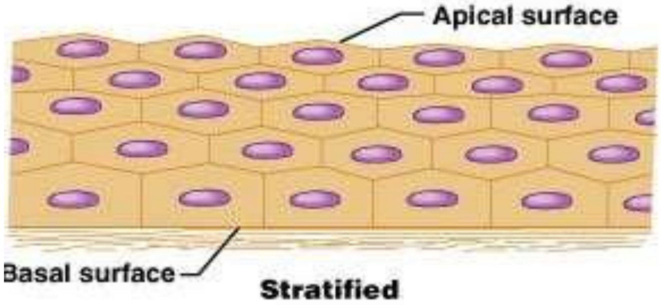
EPITHELIAL TISSUE

Simple



1. Simple Squamous
2. Simple Cuboidal
    a. Ciliated
    b. Non- ciliated
    c. Brush-bordered
3. Simple Columnar
    a. Ciliated
    b. Non- ciliated
    c. Brush-bordered

Compound

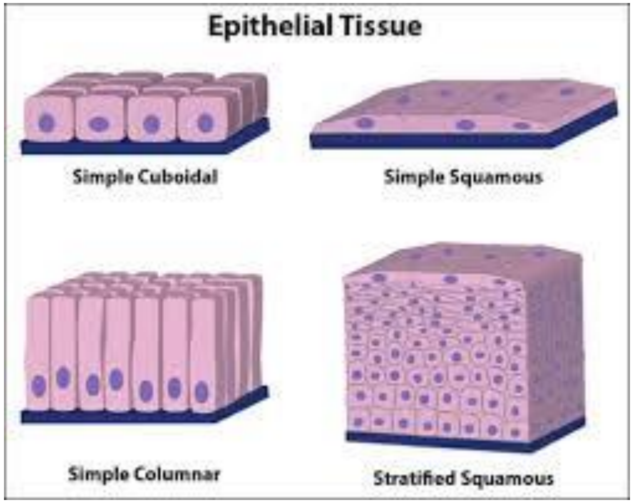


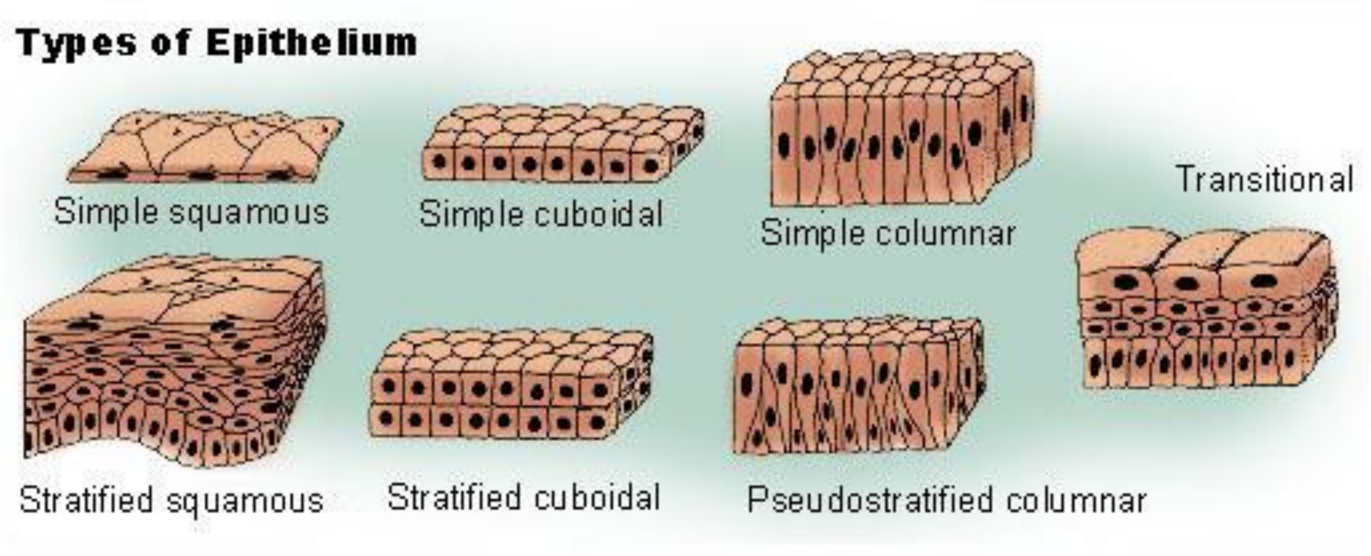
1. Stratified
2. Transitional

Specialised epithelia

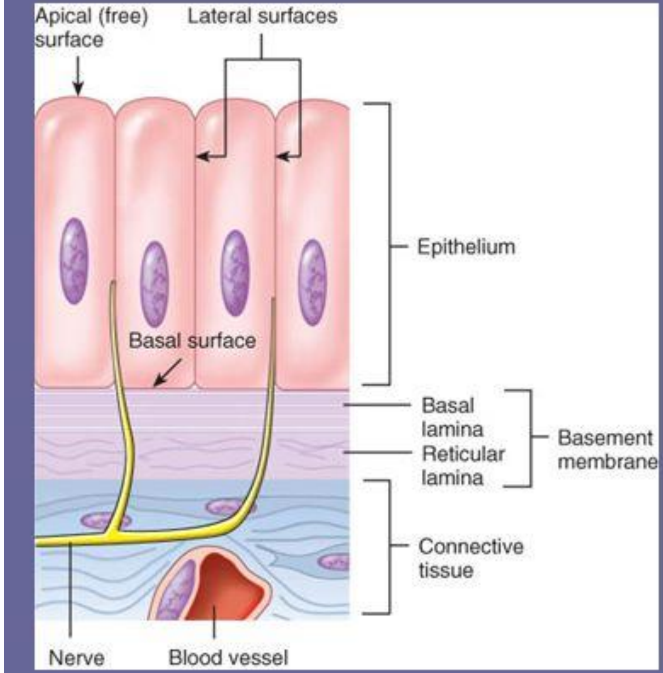
a. Glandular
b. Sensory
c. Germinal

Types of Epithelial Tissue





Basement Membrane



- Basal lamina
  - from epithelial cells
  - collagen fibers
- Reticular lamina
  - secreted by connective tissue cells
  - reticular fibers
- Functions:
  - guide for cell migration during development
  - may become thickened due to increased collagen and laminin production
- Example: In diabetes mellitus, the basement membrane of small blood vessels, especially those in the retina and kidney, thickens.

SIMPLE SQUAMOUS EPITHELIUM

Structure:

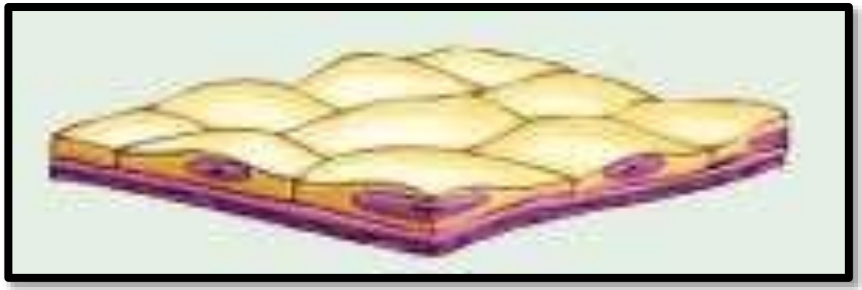
- The cells are polygonal in shape, thin, delicate and flat.
- The nucleus is centrally placed. They appear like flat tiles when viewed from the top and so they are also called *pavement epithelium.*

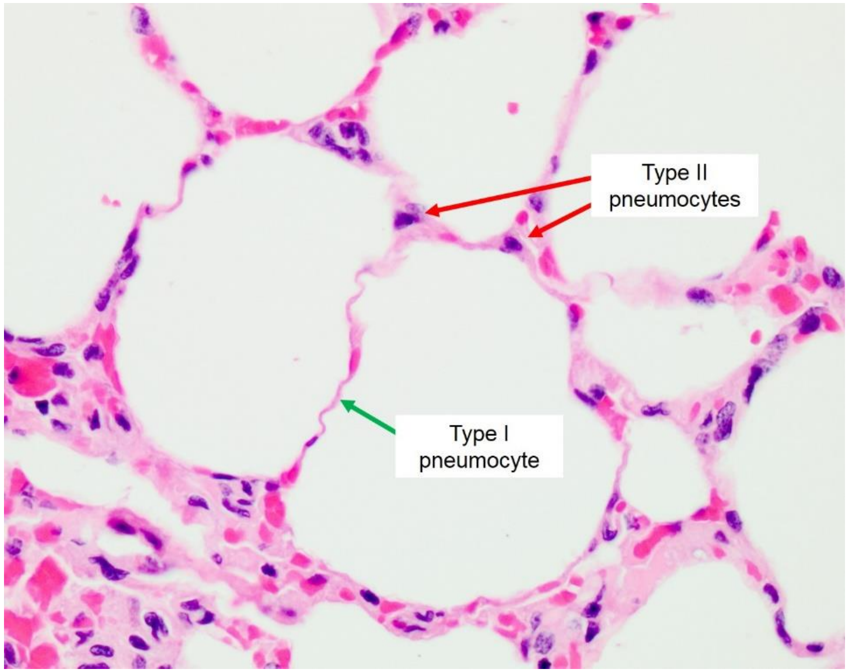
Functions:

- *Filtration* and *diffusion* of material.
- *Protection* of skin from micro-organisms and foreign particles.

Location:

- Alveoli of lungs
- Endothelium (i.e. lining of the blood and lymph vessels).





SIMPLE CUBOIDAL EPITHELIUM

Structure:

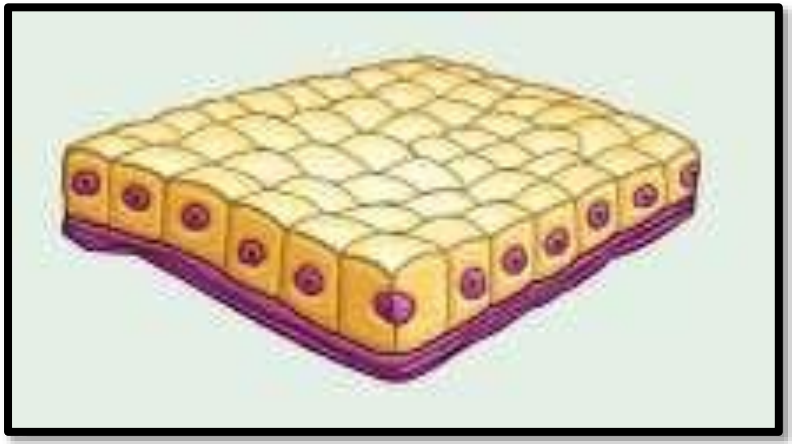
-The cells are cube shaped, with centrally placed spherical nucleus.

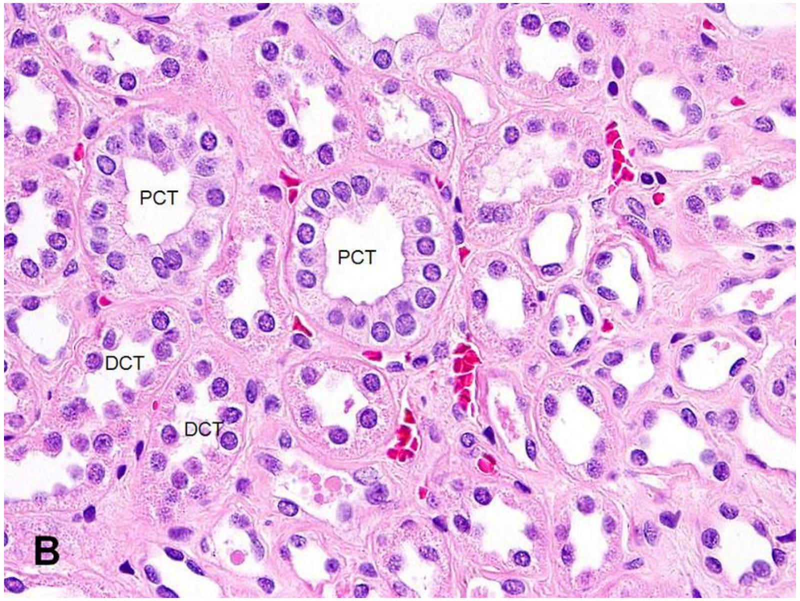
Functions:

- They play an important role in *absorption* and *secretion*.

Location:

- It is generally found in glands and kidney.
  - Duct of salivary glands and pancreas.
  - Tubular part of kidney nephron (brush-bordered and simple).
  - *Germinal epithelium*





Histology of kidney tubule

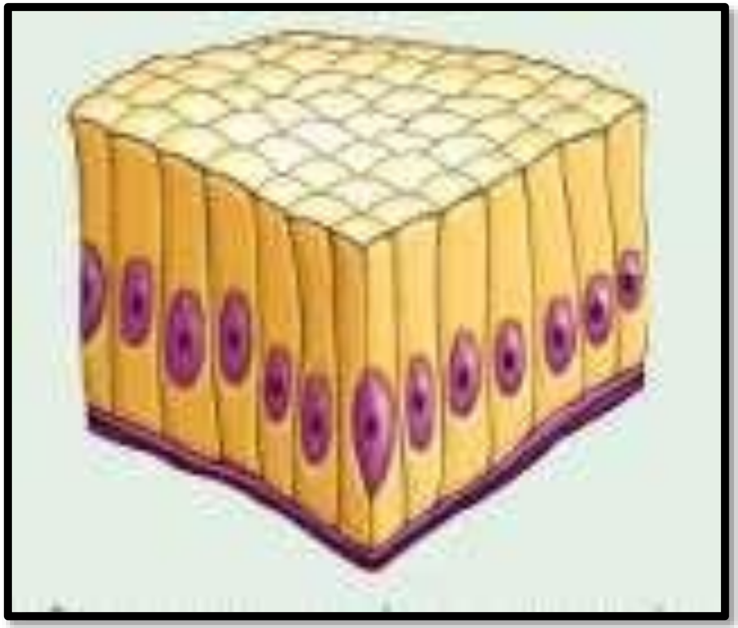
SIMPLE COLUMNAR EPITHELIUM

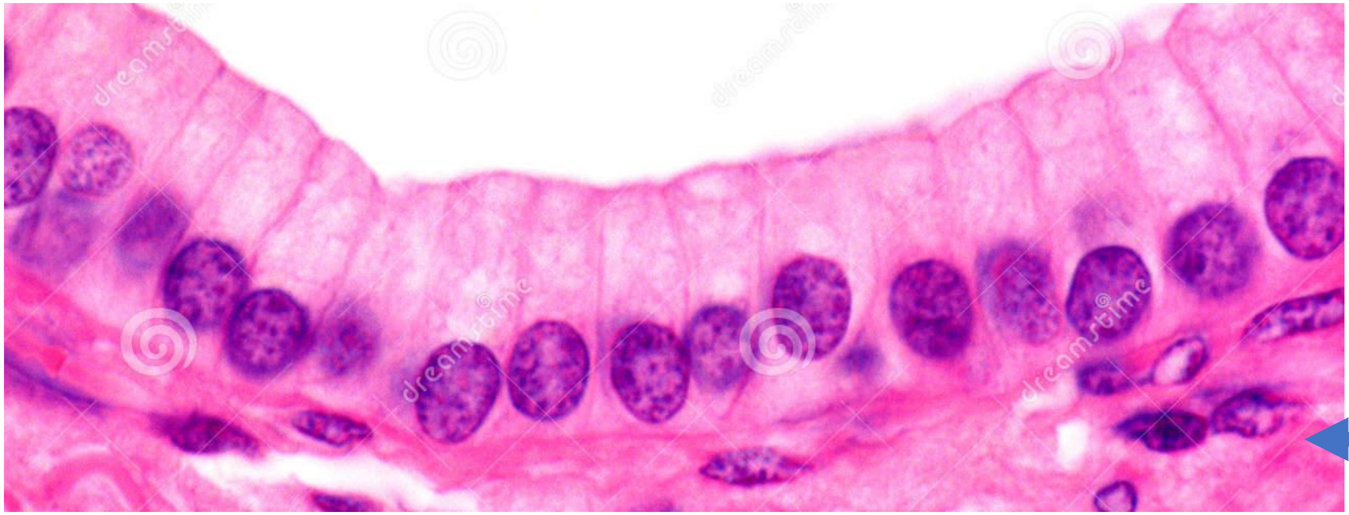
Structure:

- The cells are tall, pillar-like with anterior free end that is broader than the posterior narrow end resting on the basement membrane.
- Nucleus is oval or elliptical and is placed near the basal end.

Location:

- It makes the inner lining of stomach, intestine and other internal organs.





dreamstime

In pancreatic duct

CILIATED COLUMNAR EPITHELIUM

Structure:

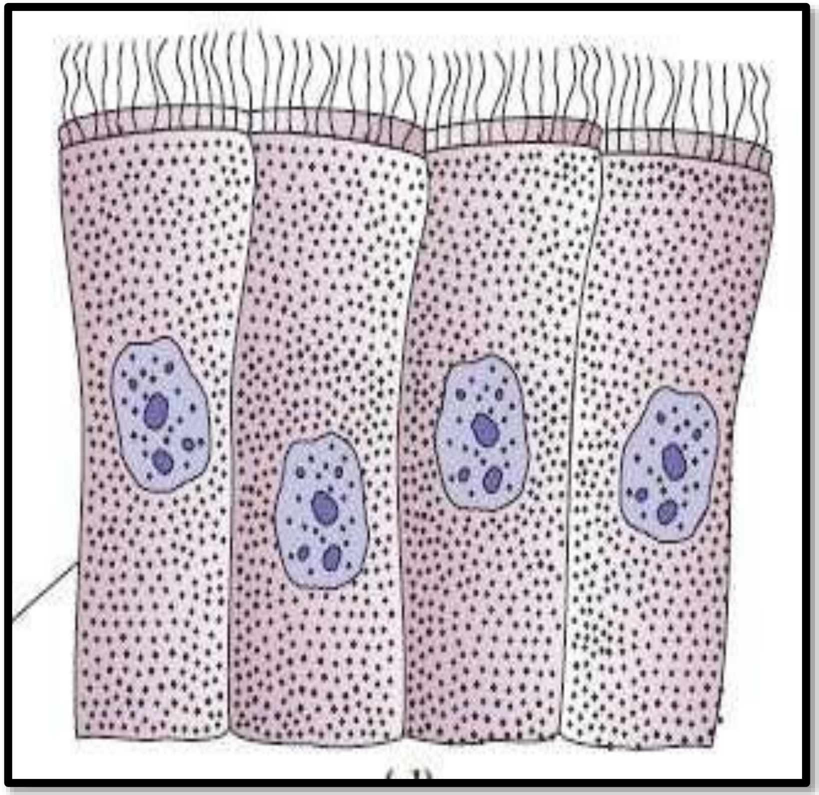
- The anterior free end shows presence of large number of thin **hair-like extensions** called **cilia.**

Location:

- It is found in the upper respiratory tract, fallopian tube of vertebrates.

Functions:

- Since cilia are capable of **vibratory movement**, they are able to remove foreign particles from the surface.
- Cilia help in the movement of non-motile ovum.



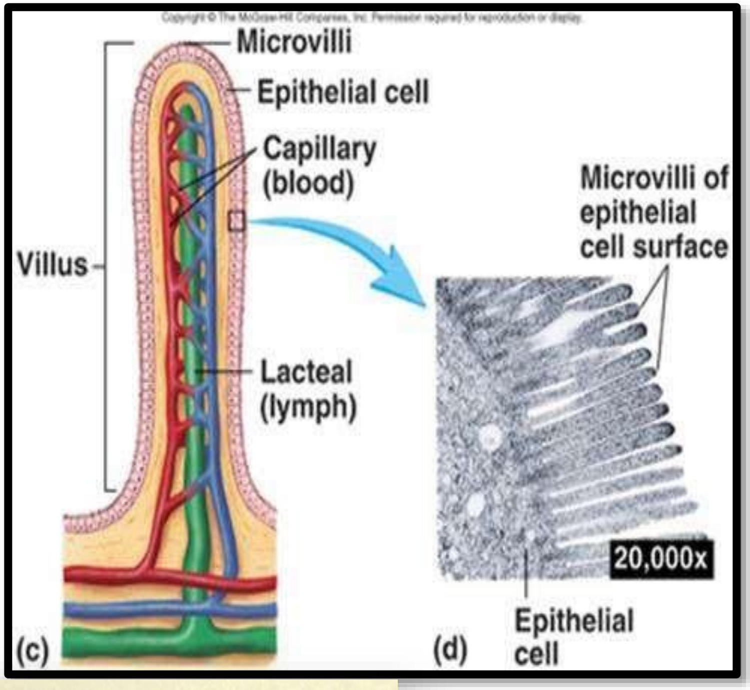
NON-CILIATED COLUMNAR EPITHELIUM

Structure:

- These are without cilia at their anterior free end and hence called non-ciliated columnar epithelium.
- Columnar cells at their apical region show presence of finger like protoplasmic projections called microvilli **– brush-bordered.**

Functions:

Microvilli help in increasing the surface area of **absorption** which is the main function of non-ciliated columnar epithelium.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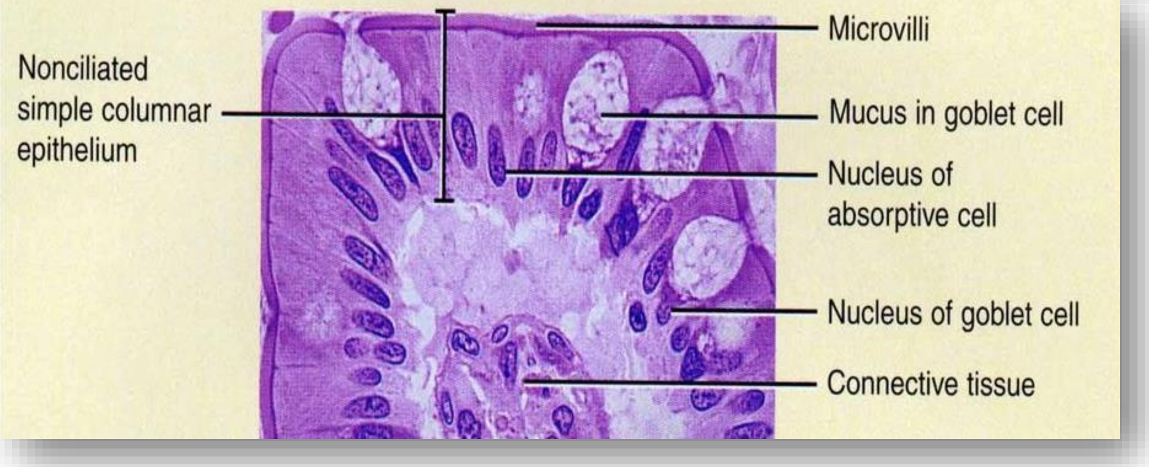
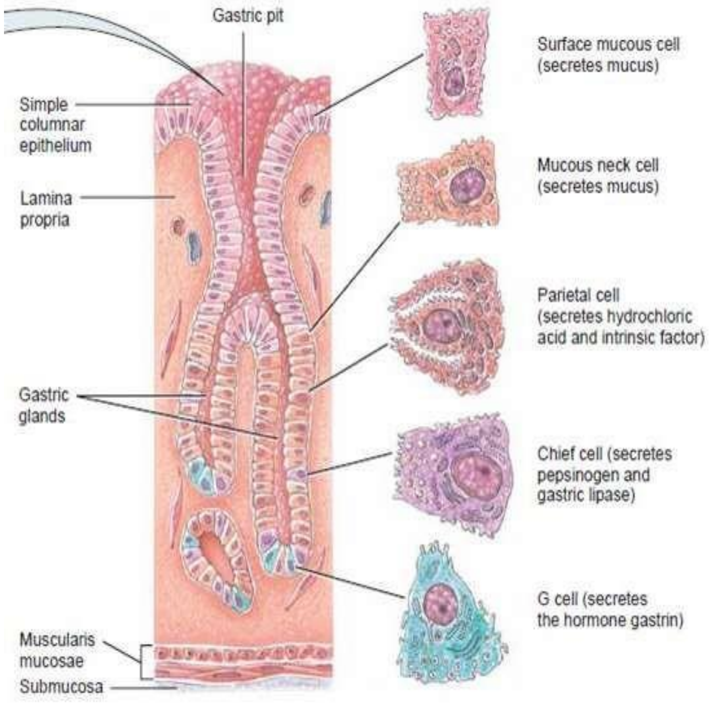


GLANDULAR EPITHELIUM

- These are specialized epithelial cells capable of synthesizing substances like enzymes, hormones, sweat, oil, etc.
- These secretions are carried into ducts (tubes) on the surface or into blood.
- The structure formed by these specialized epithelial cells is commonly called a ***GLAND.***
- Glands are further classified as:


Gastric pit
Simple columnar epithelium
Lamina propria
Gastric glands
Muscularis mucosae
Submucosa
Surface mucous cell (secretes mucus)
Mucous neck cell (secretes mucus)
Parietal cell (secretes hydrochloric acid and intrinsic factor)
Chief cell (secretes pepsinogen and gastric lipase)
G cell (secretes the hormone gastrin)

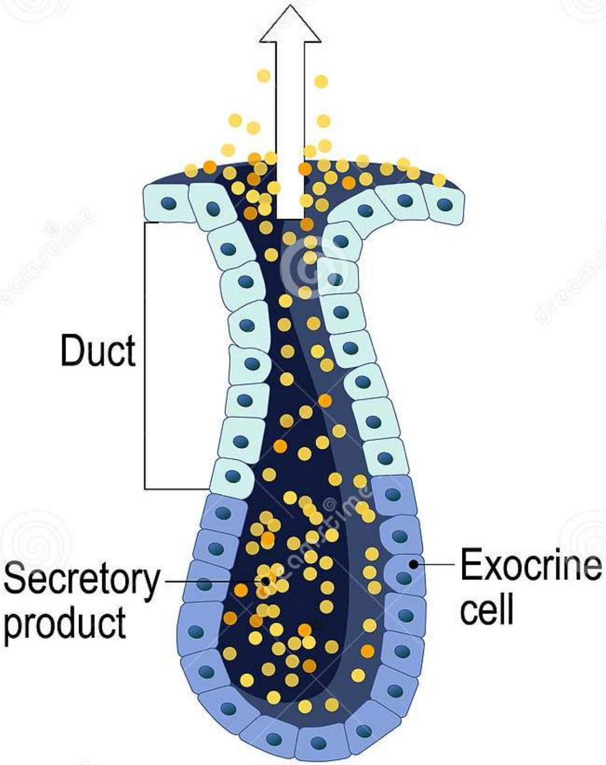
Endocrine Glands:

- These glands pour their secretion directly into the blood stream. Such glands lack ducts and are thus called **ductless glands**.
- e.g.: pituitary, thyroid, parathyroid, ovary, testis, adrenal, islets of Langerhans.

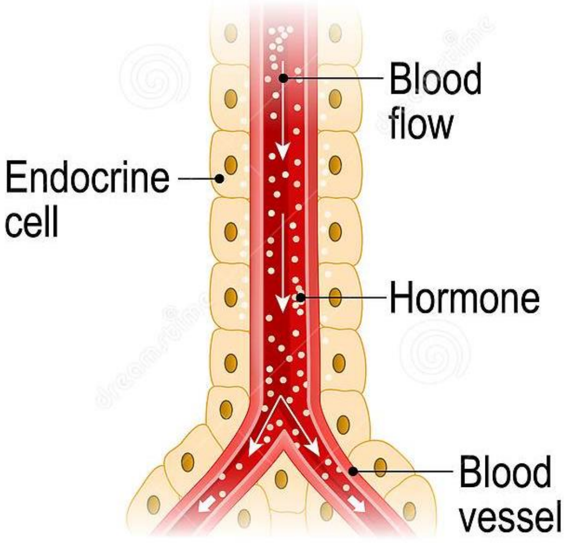
Exocrine Glands:

- These glands are **with ducts**. Their secretion is carried by means of a duct or tube to the site of action. They are responsible for body secretions.
- e.g.: tear glands, salivary glands, gastric and intestinal glands.

Types of gland

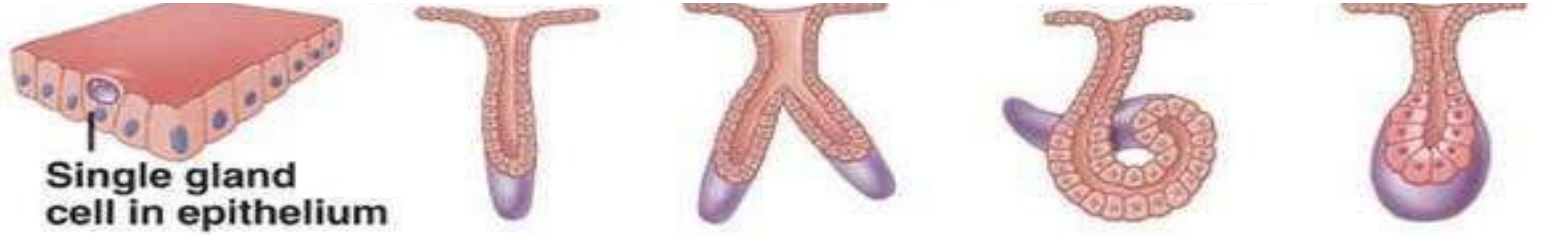


Exocrine gland



Endocrine gland

Gland - Types



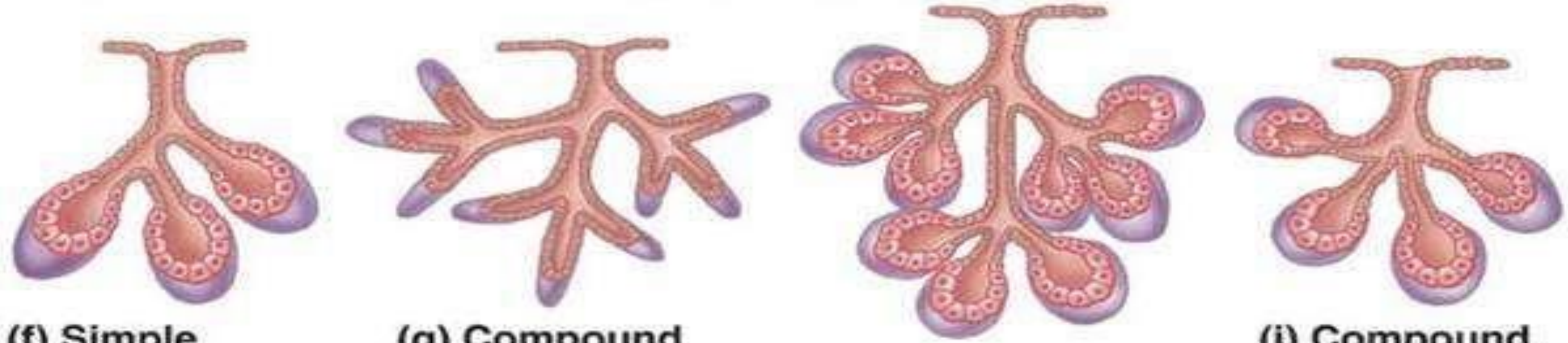
(a) Unicellular (goblet cells in large and small intestine and respiratory passages)

(b) Simple straight tubular (glands in stomach and colon)

(c) Simple branched tubular (glands in lower portion of stomach)

(d) Simple coiled tubular (lower portion of stomach and small intestine)

(e) Simple acinar (sebaceous glands of skin)



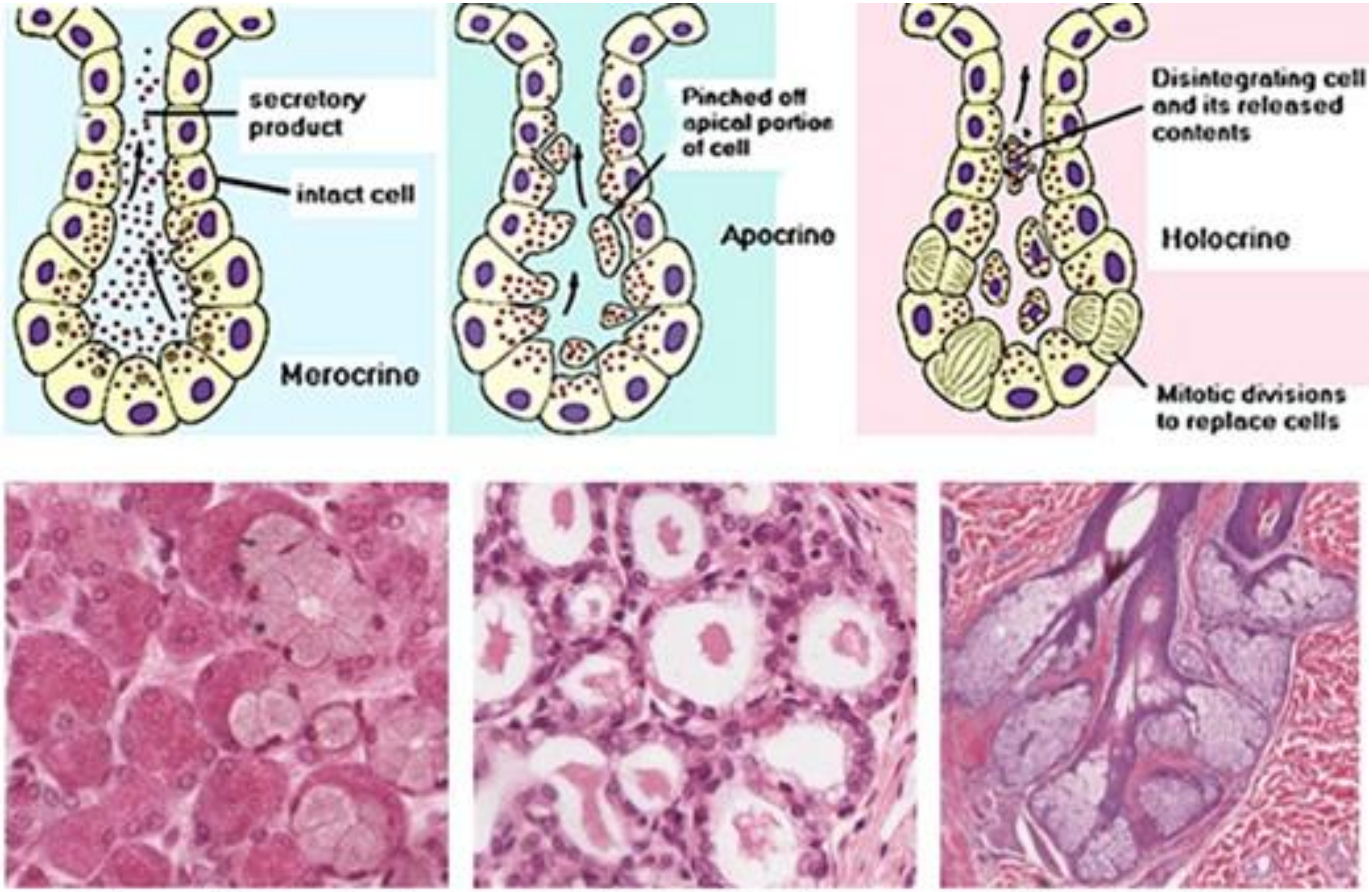
(f) Simple branched acinar (sebaceous glands of skin)

(g) Compound tubular (mucous glands of duodenum)

(h) Compound acinar (mammary glands)

(i) Compound tubuloacinar (pancreas)

Exocrine Gland - Types


secretory product
intact cell
Merocrine
Pinched off apical portion of cell
Apocrine
Disintegrating cell and its released contents
Holocrine
Mitotic divisions to replace cells

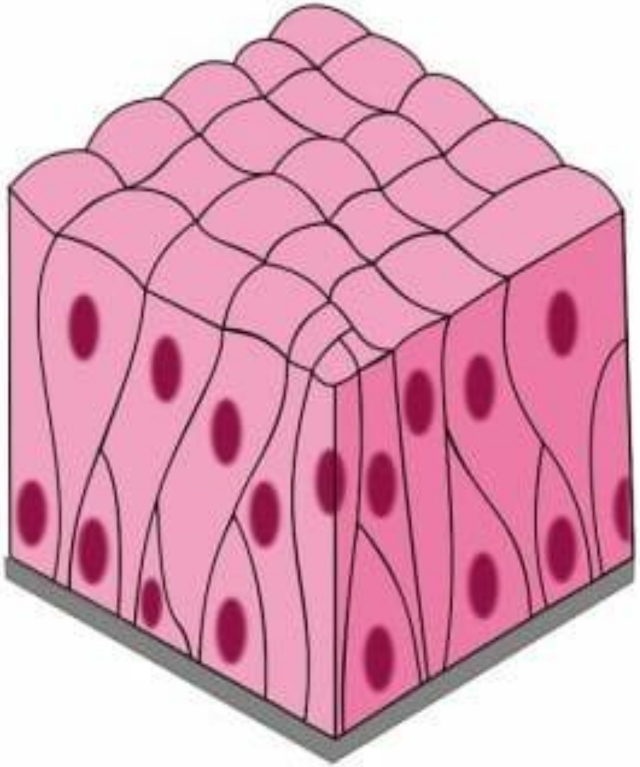
Submandibular gland

Mammary gland

Sebaceous gland

Pseudostratified Epithelium

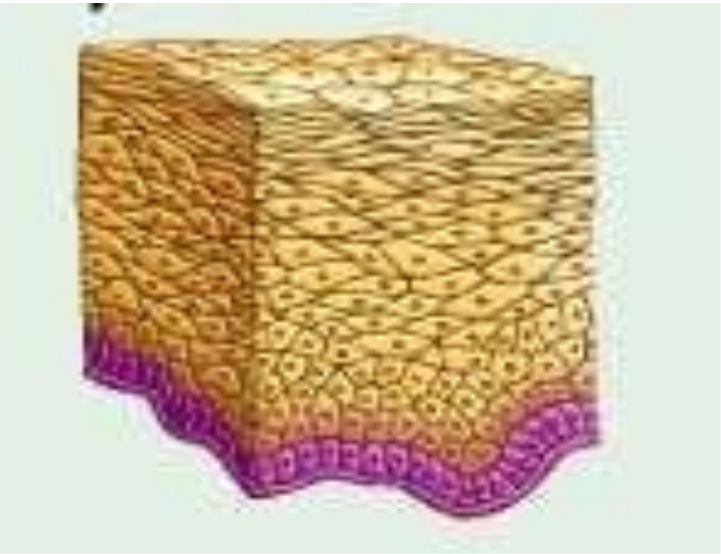
- Structure
  - Irregularly shaped cells with nuclei at different levels – appear stratified, but aren't.
  - All cells reach basement membrane
- Function
  - Absorption and Secretion
  - Goblet cells produce mucus
  - Cilia (larger than microvilli) sweep mucus
- Location
  - Respiratory Linings & Reproductive tract

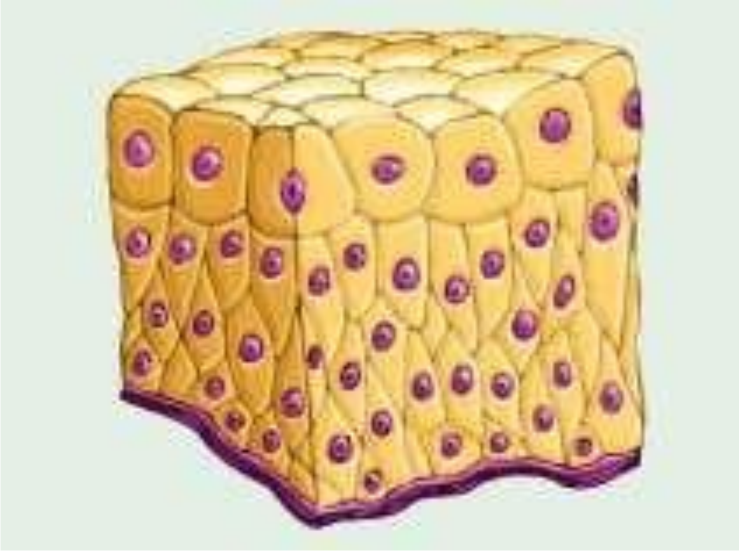


COMPOUND EPITHELIUM

1. STRATIFIED EPITHELIUM

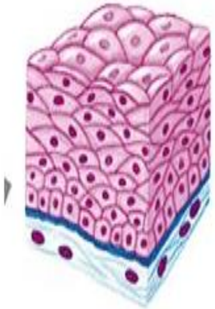
2. TRANSITIONAL EPITHELIUM



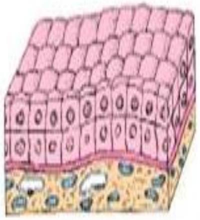


STRATIFIED EPITHELIUM

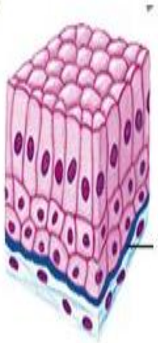
What cell is on the top layer?



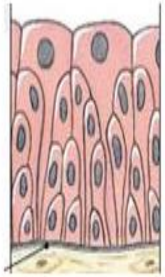
- Stratified sqamous epithelium



- Stratified cuboidal epithelium

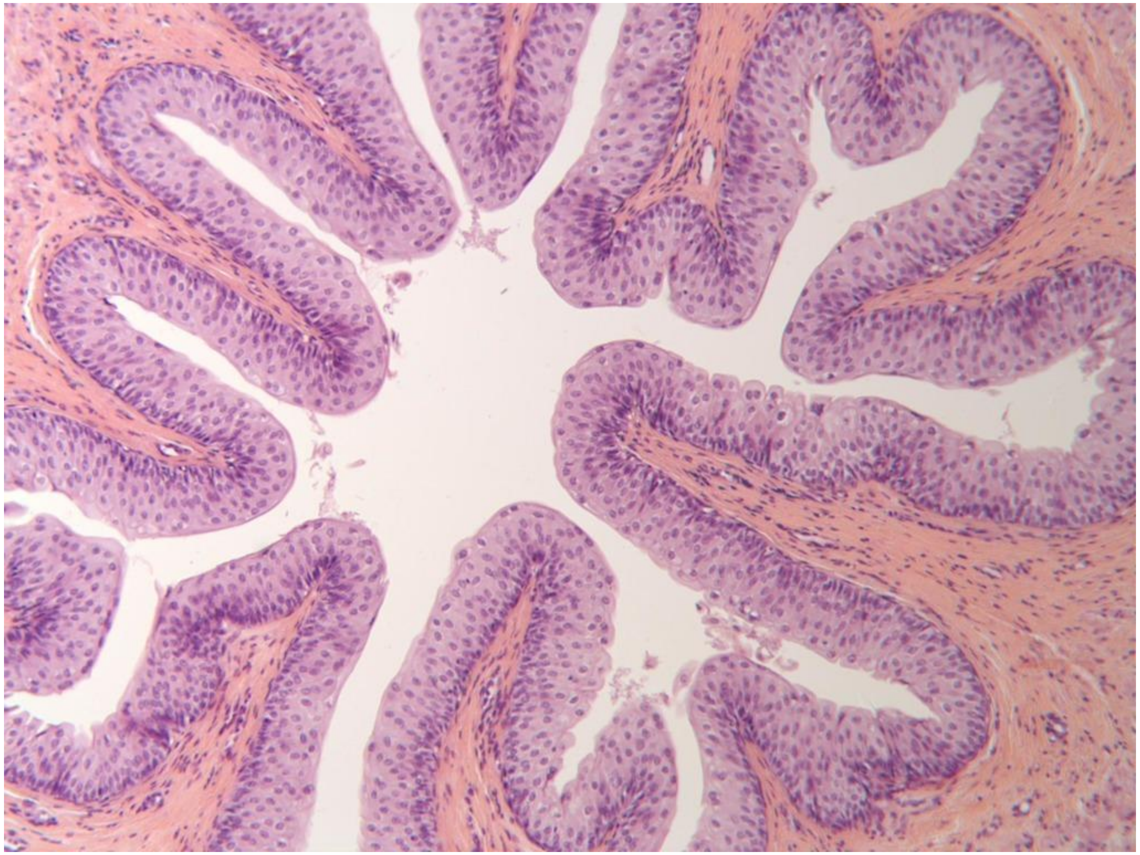


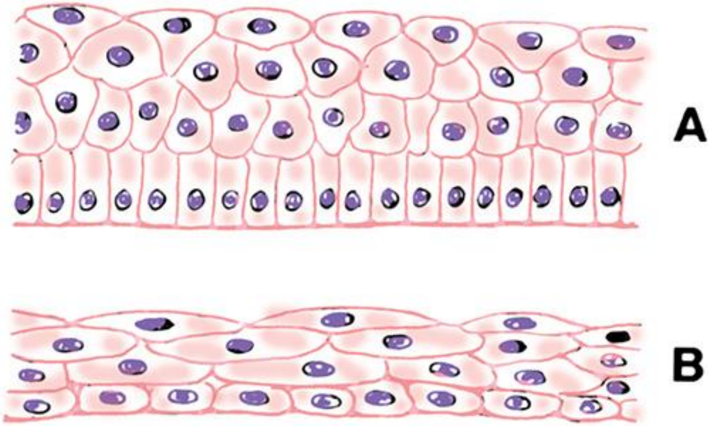
- Stratified columnar epithelium



- Transitional epithelium

TRANSITIONAL EPITHELIUM

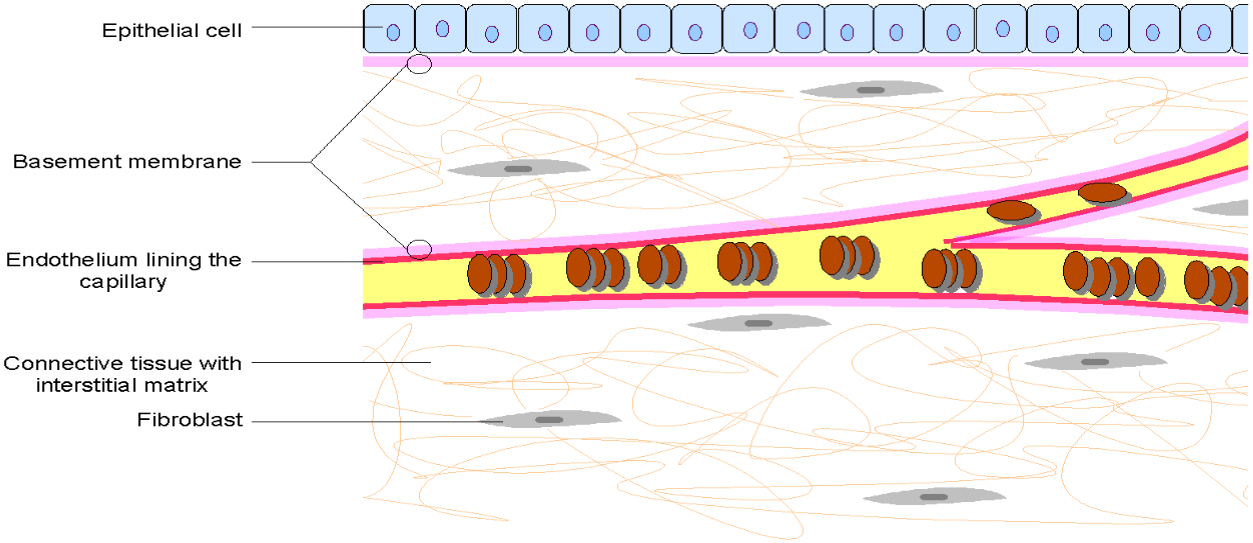




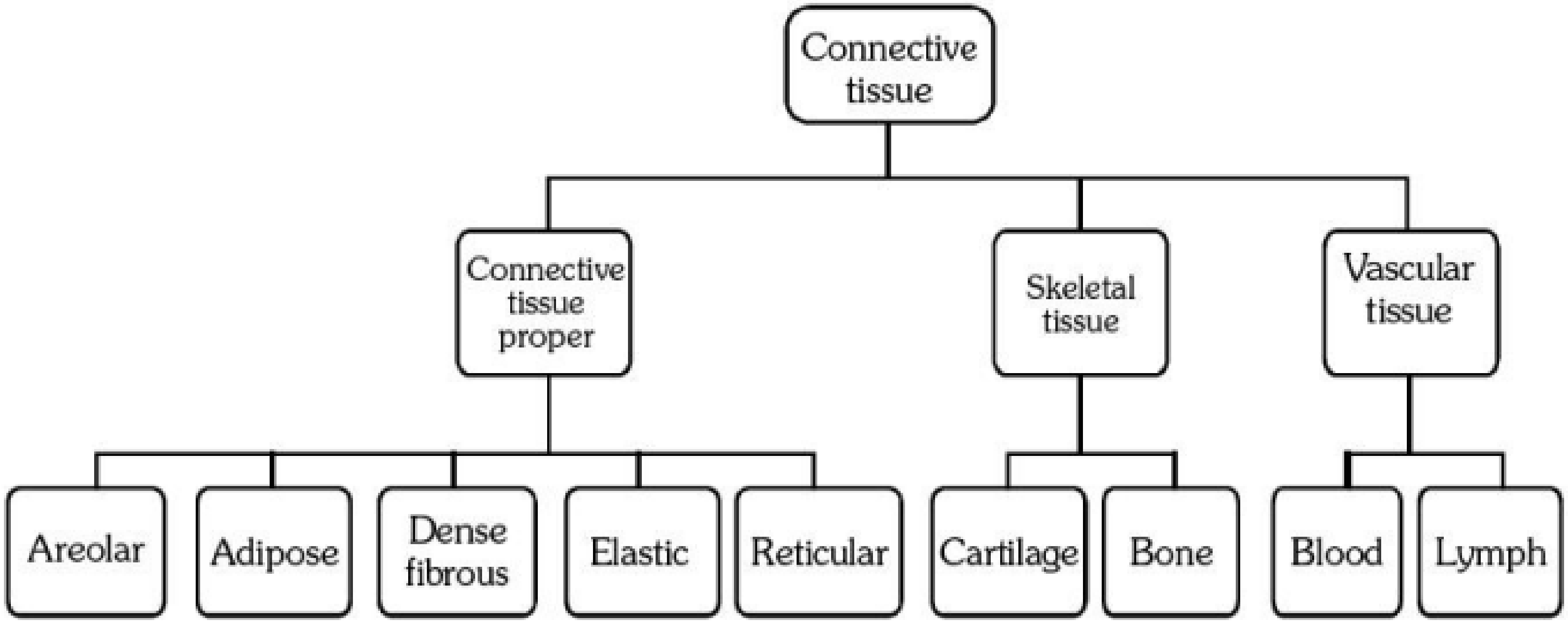
CONNECTIVE TISSUE

- Varied cells with intercellular space.
- Found in every body organ, fills spaces.
- Components – cells, matrix (intercellular medium), fibers
- Fibers – collagen, elastin, reticular fibers (exception – vascular connective tissue)
- Matrix – glycosaminoglycans and glycoproteins
- Cells
  - ○Fibroblasts
  - ○Mast cells – produce histamine, serotonin, heparin
  - ○Plasma cells – produce antibodies
  - ○Macrophages

Illustration depicting extracellular matrix in relation to epithelium, endothelium and connective tissue

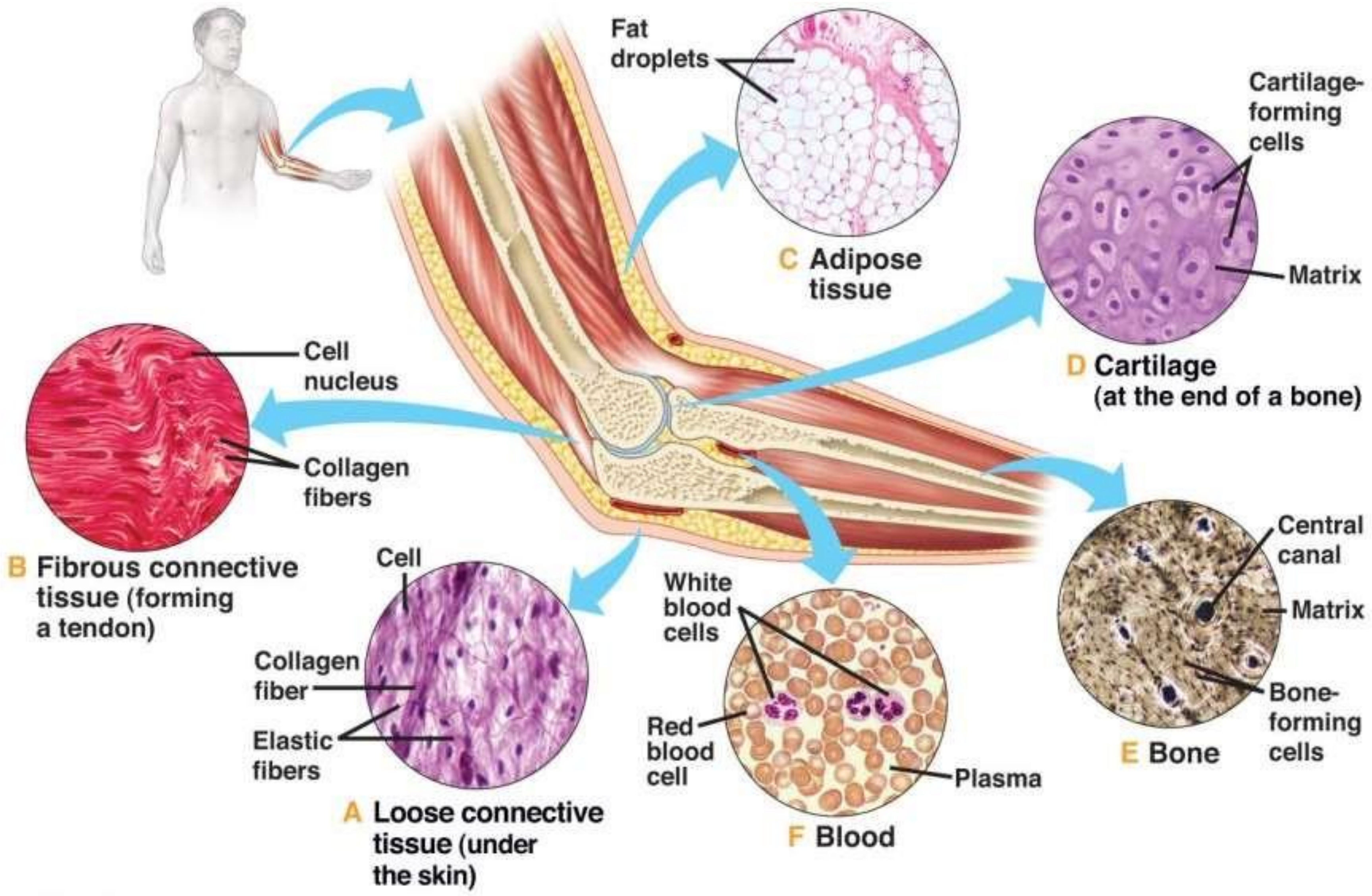

Epithelial cell
Basement membrane
Endothelium lining the capillary
Connective tissue with interstitial matrix
Fibroblast

CONNECTIVE TISSUE - Classification



- Connective tissue
  - Connective tissue proper
    - Areolar
    - Adipose
    - Dense fibrous
    - Elastic
    - Reticular
  - Skeletal tissue
    - Cartilage
    - Bone
  - Vascular tissue
    - Blood
    - Lymph

CONNECTIVE TISSUE



Connective tissue proper

Areolar tissue

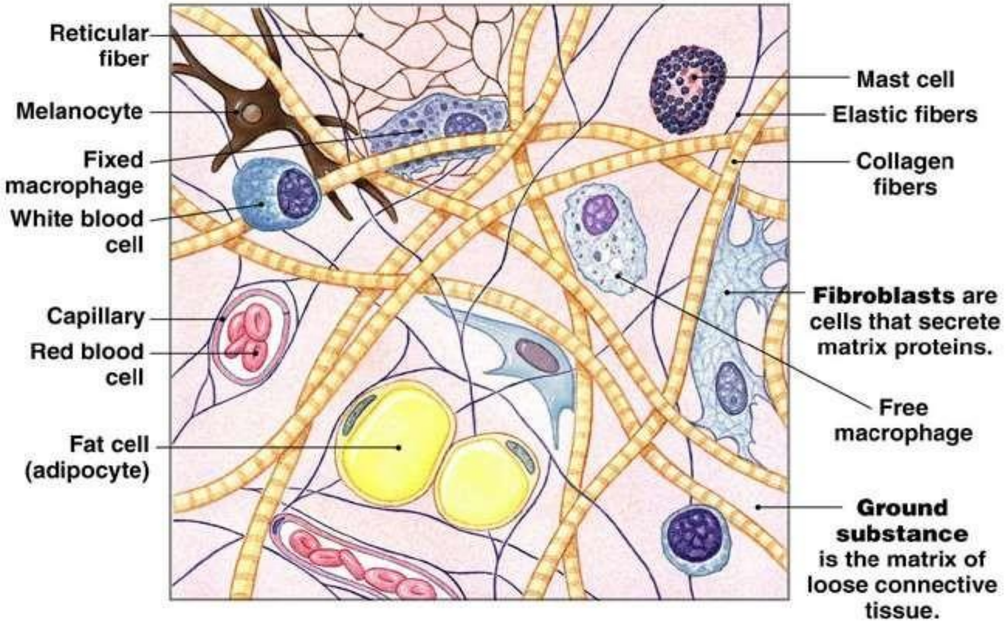
Location:

-It is found below the skin, aroud blood vessels, muscles and bones, etc.

-Packing tissue of animals.

Functions:

- Also called *loose connective tissue*, is essentially connective in function.



Adipose tissue

Location:

- The adipose tissue is found in the **subcutaneous** tissue (under the skin), in the covering of the heart and other major organs, and around the blood vessels.
- It also forms the **yellow bone marrow**.

Functions:

- Adipose tissue is primarily a **food reserve**.
- The subcutaneous fat prevents heat loss from the body, particularly in polar animals and also rounds off the body contour (shape).
- It forms a shock absorbing cushion around the kidneys and the eyeballs.
- It also produces the blood corpuscles.

Structure:

- It is modified areolar tissue consisting of a large number of **adipocytes** i.e. cells specialized for fat storage. A fat cell first develops in it small fat droplets, which later fuse to form a large fat globule. These globules push the cytoplasm with its organelles to the periphery and the nucleus to one side.

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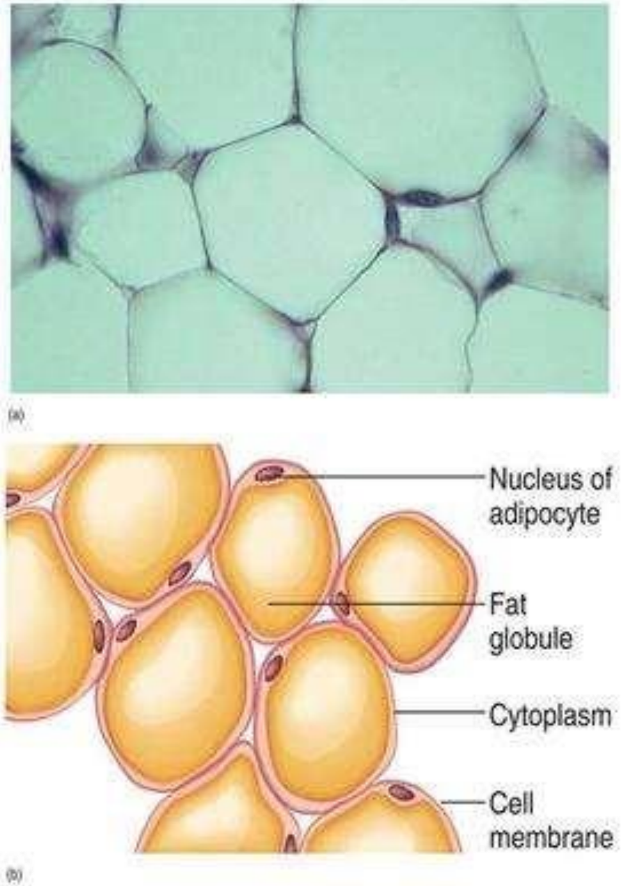
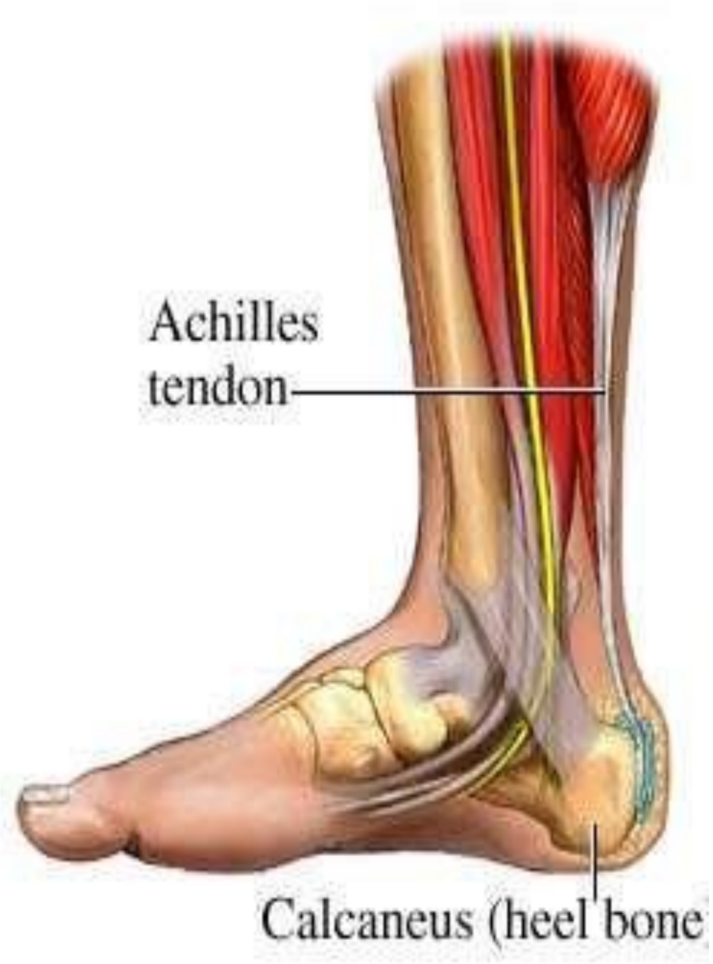


Photo A © Ed Reschke

Dense (White) Fibrous Tissue

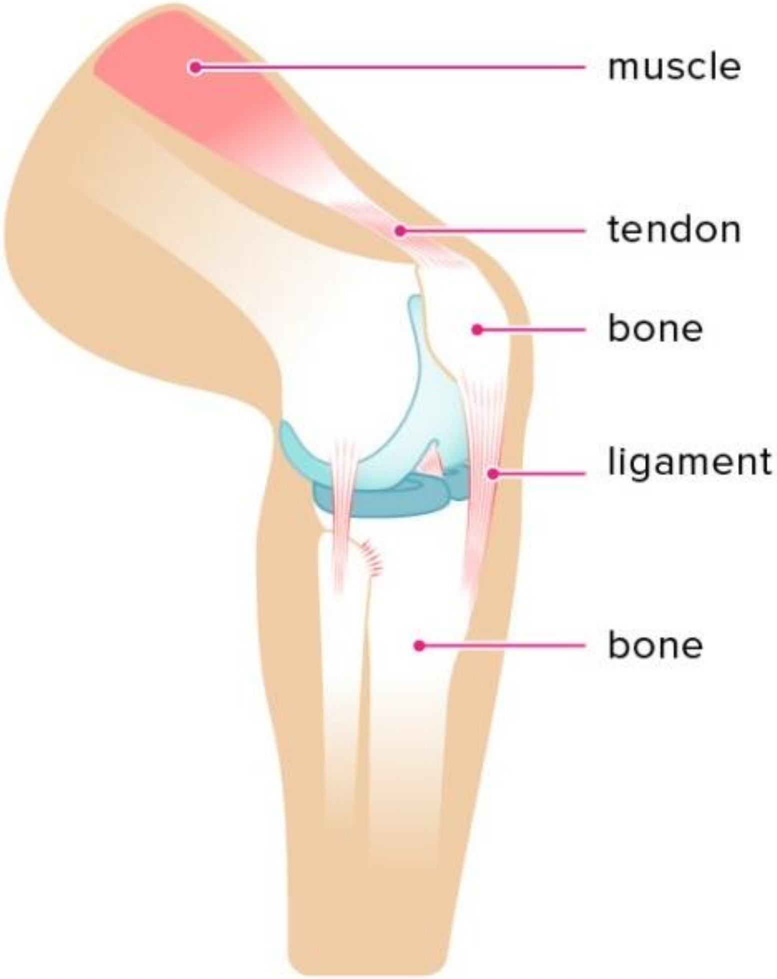
- The white fibrous tissue is especially rich in white collagen fibres.
- These are similar to but thicker than those found in the areolar tissue.
- This tissue is very tough and ***inelastic***. It appears as *cords or sheets*.
- As cords, the white fibres run longitudinally and parallelly. Eg. *tendons*.
- ***Tendons connect the skeletal muscles with the bones.***
- Some of the tendons are – **Achilles tendon, hamstring tendon.**
- As sheets**,** it occurs in the pericardium of the heart, dura mater of the brain and spinal cord, capsule of the kidney, etc.



Yellow Elastic Tissue

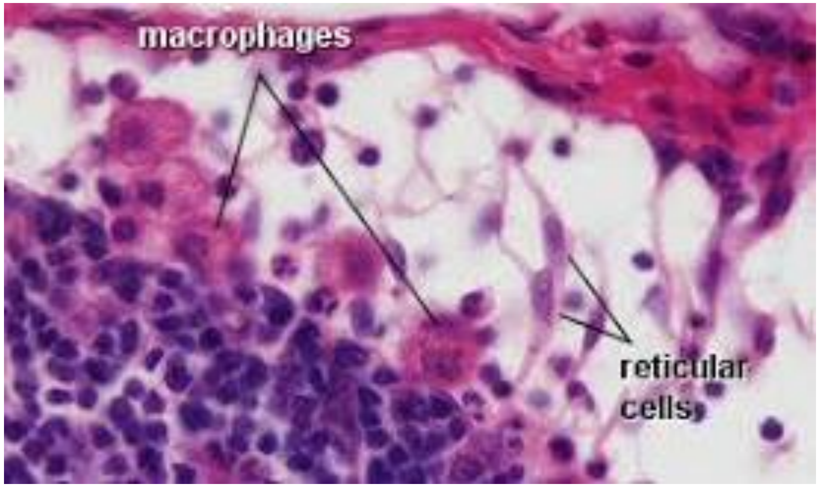
- The yellow elastic tissue consists mainly of a loose network of yellow elastic fibres.
- These elastic fibres are much thicker but similar to those of areolar tissue.
- This tissue combines strength with great flexibility. It also has 2 forms: cords and sheets.
- The **cords** formed by this tissue are called **ligaments.**

  Ligaments serve to bind the bones together.
- As **sheets**, they occur in the walls of the blood vessels, lungs and bronchioles.
- **Recovery of these organs after expansion** is due to this tissue's presence.



Reticular tissue

- The reticular tissue consists of star-shaped **reticular cells**, the protoplasmic processes of which join to form a cellular network.
- **Reticular fibres** are superimposed on the reticular cells. They are composed of a protein called **reticulin**.
- They are branched and inelastic.
- This tissue forms the supporting framework of lymph glands, spleen and bone marrow.

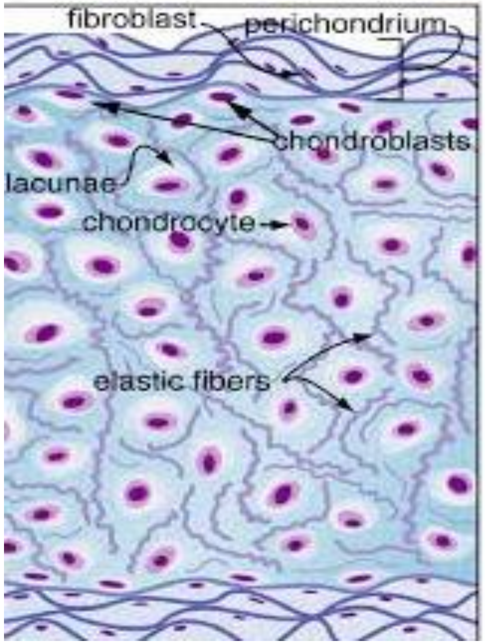


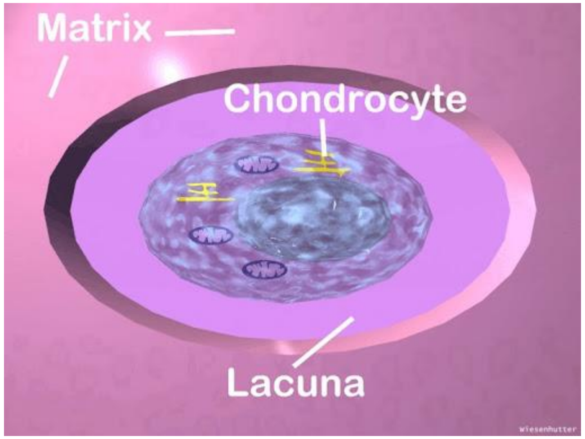
Skeletal Tissue - cartilage

The cartilage is a solid, semi-rigid connective tissue. It is tough, flexible tissue which forms the endoskeleton in large number of vertebrates.

Structure:

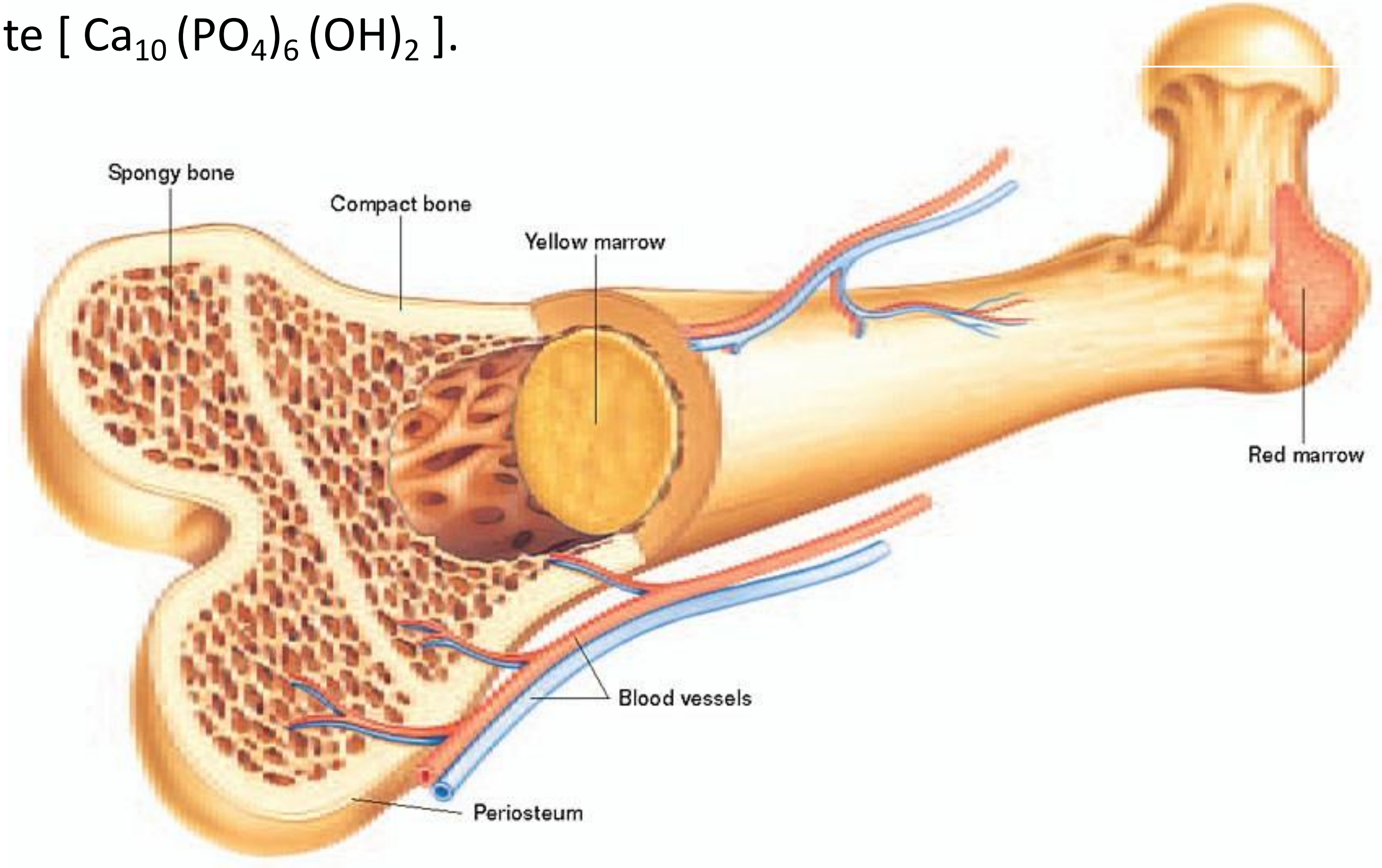
- The cartilage is enclosed in a sheath of white fibrous tissue called **perichondrium.** It consists of blood vessels and nerve fibres.
- The perichondrium encloses a semi-solid matrix made up of **chondrin.**
- Towards the periphery or the inner margin of the perichondrium, a layer of small immature cartilage cells called **chondroblasts** are seen. The matrix is secreted by the chondroblasts.
- Mature cells are called as chondrocytes.
- Cells lie in a fluid-filled space, the cartilage **lacuna**, in the matrix.
- During growth of the cartilage, the chondroblasts divide and the cells formed by division keep lying in groups of two or more in the same lacuna.

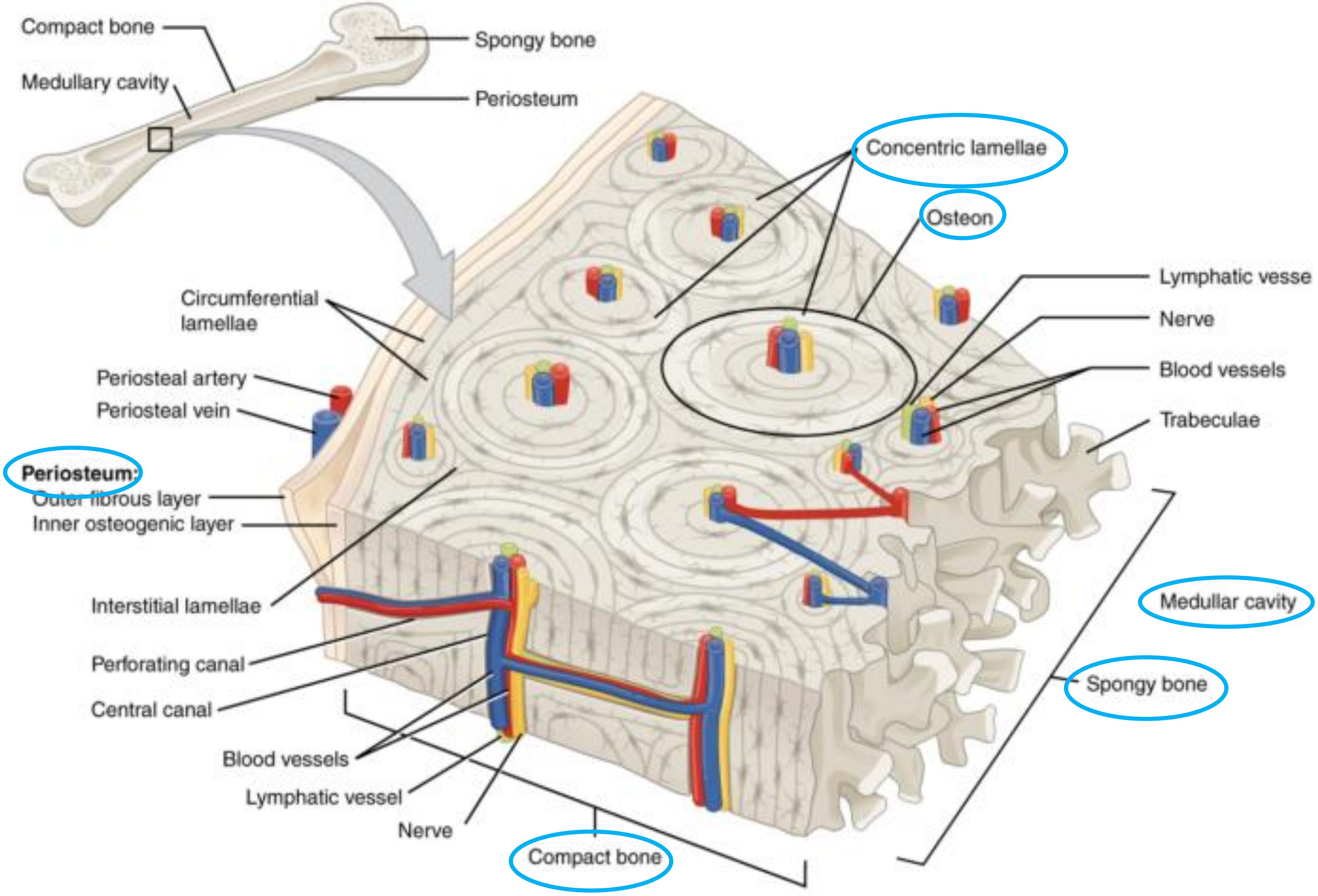


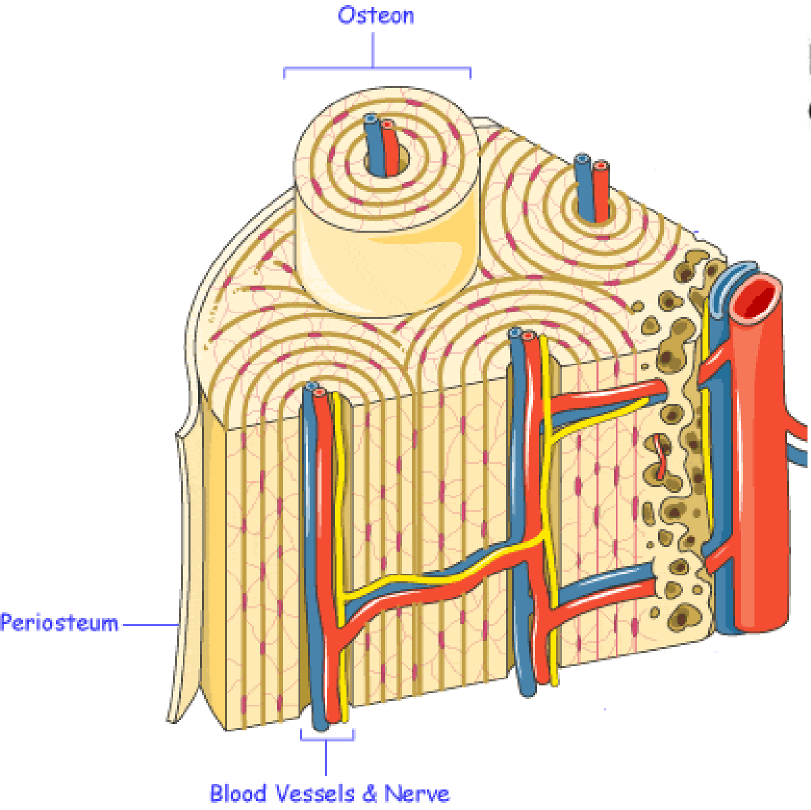


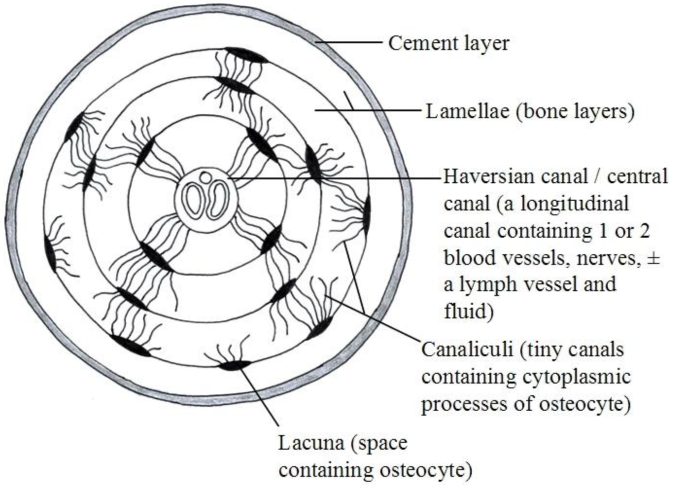
Skeletal Tissue - Bone

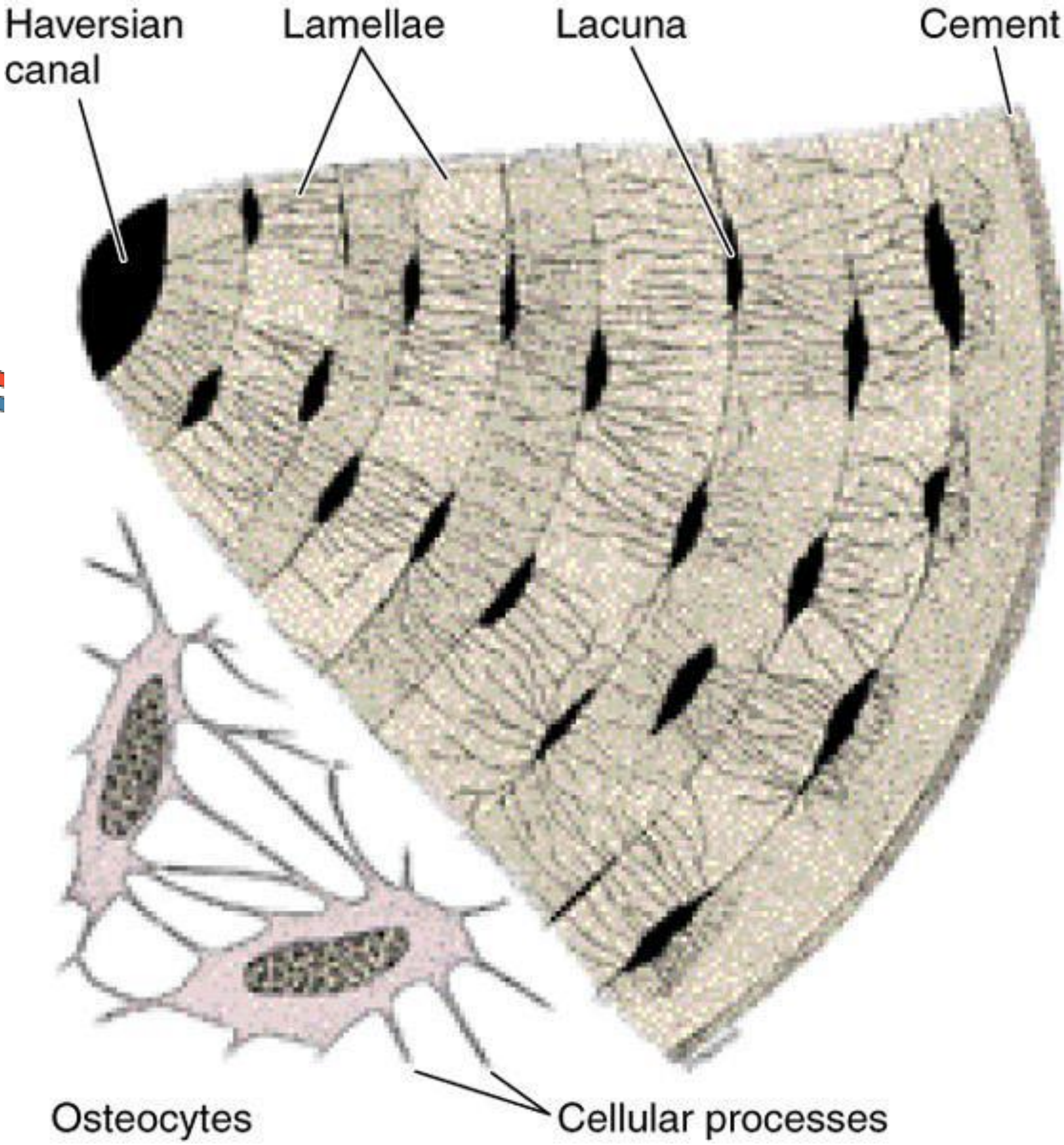
- Bone is the hardest tissue in the body.
- It is the main constituent of the skeleton.
- It shows the presence of hard, solid, calcified matrix called ossein.
- The hardness is due to deposition of inorganic mineral salt called hydroxyl-apatite [$Ca_{10}(PO_4)_6(OH)_2$].



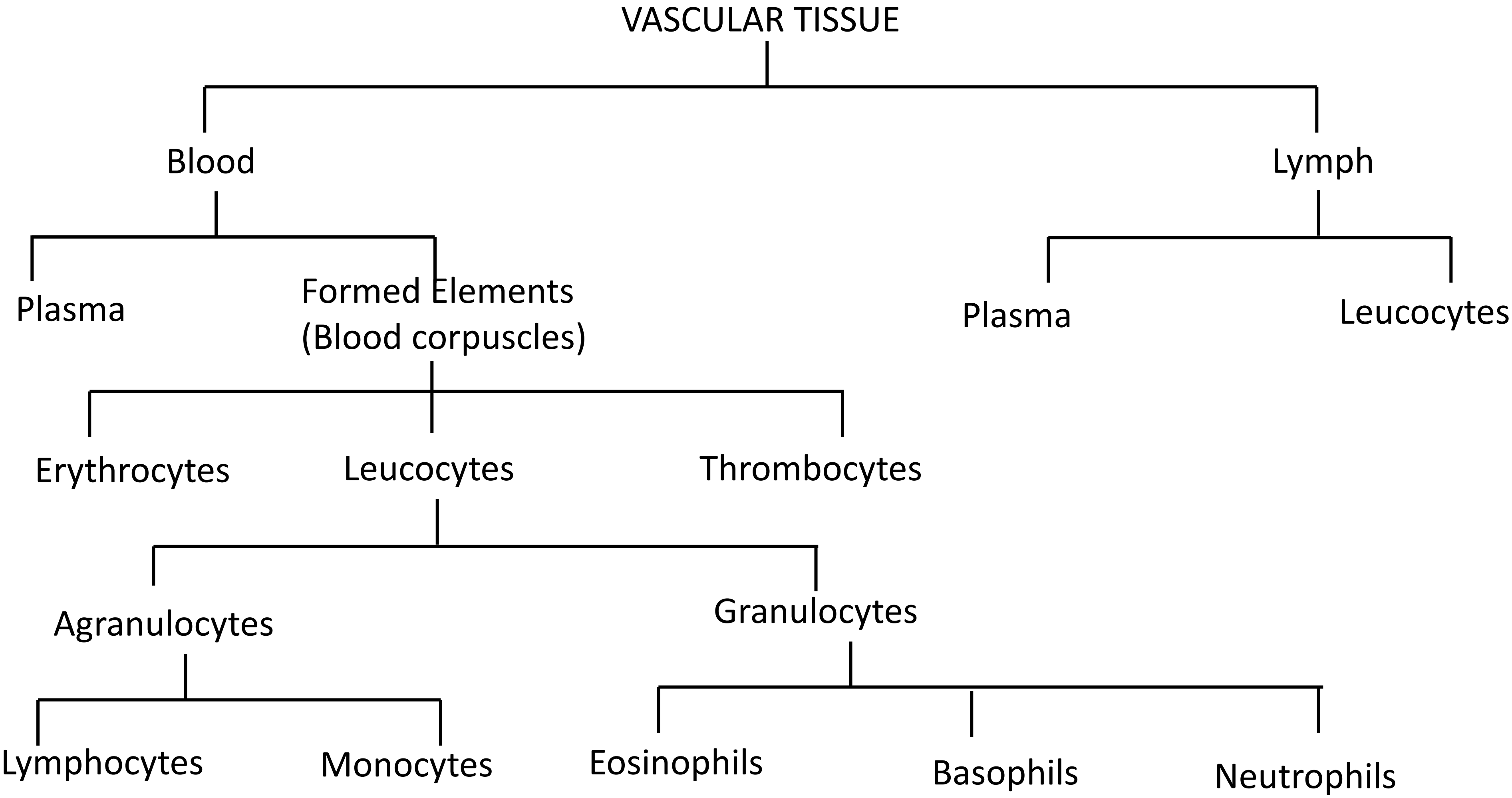

Compact bone
Medullary cavity
Spongy bone
Periosteum
Concentric lamellae
Osteon
Circumferential lamellae
Lymphatic vesse
Nerve
Periosteal artery
Periosteal vein
Blood vessels
Trabeculae
Periosteum:
Outer fibrous layer
Inner osteogenic layer
Interstitial lamellae
Medullar cavity
Perforating canal
Central canal
Spongy bone
Blood vessels
Lymphatic vessel
Nerve
Compact bone


Osteon
Periosteum
Blood Vessels & Nerve


Cement layer
Lamellae (bone layers)
Haversian canal / central canal (a longitudinal canal containing 1 or 2 blood vessels, nerves, ± a lymph vessel and fluid)
Canaliculi (tiny canals containing cytoplasmic processes of osteocyte)
Lacuna (space containing osteocyte)


Haversian canal
Lamellae
Lacuna
Cement
Osteocytes
Cellular processes

VASCULAR TISSUE



- Blood
  - Plasma
  - Formed Elements (Blood corpuscles)
    - Erythrocytes
    - Leucocytes
      - Agranulocytes
        - Lymphocytes
        - Monocytes
      - Granulocytes
        - Eosinophils
        - Basophils
        - Neutrophils
    - Thrombocytes
- Lymph
  - Plasma
  - Leucocytes

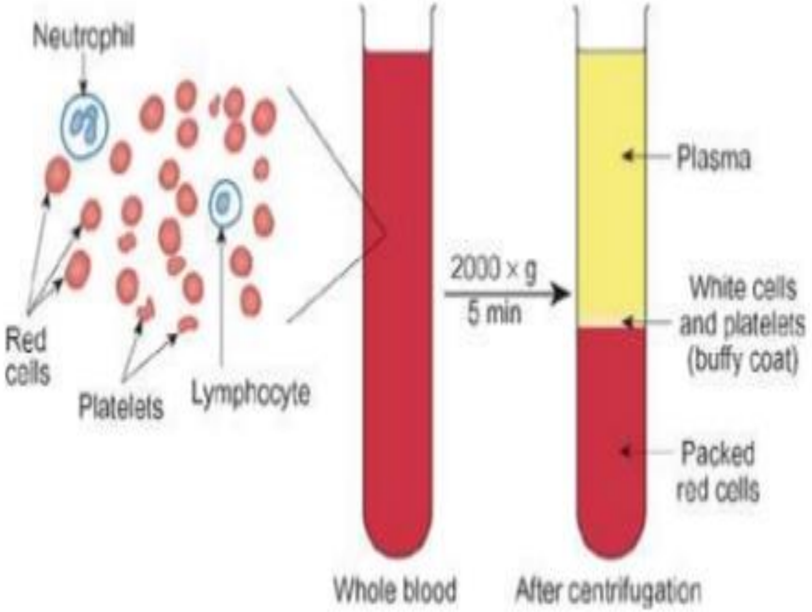
Composition of blood

Blood is composed of mainly two parts:

- Plasma
- Blood cells

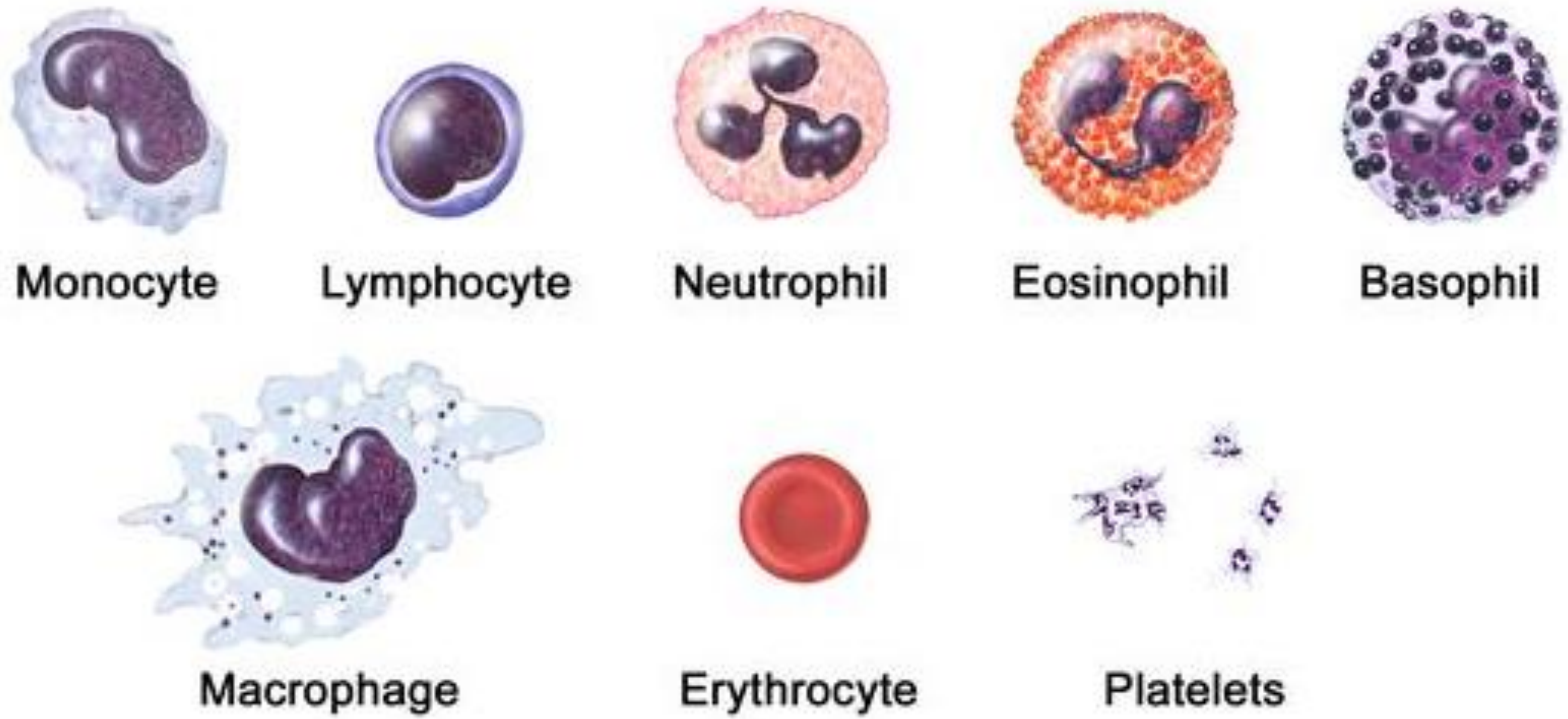
Blood cells:

1. Erythrocyte/RBC
2. Leukocyte/WBC
3. Thrombocyte/Platelet



Hematocrit

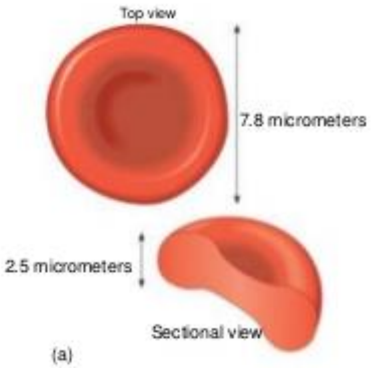
Blood Cells

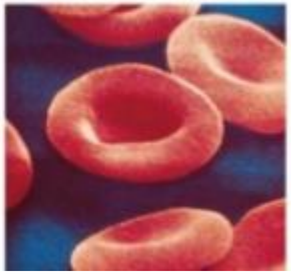

Monocyte
Lymphocyte
Neutrophil
Eosinophil
Basophil
Macrophage
Erythrocyte
Platelets

Characteristics of Red Blood Cells

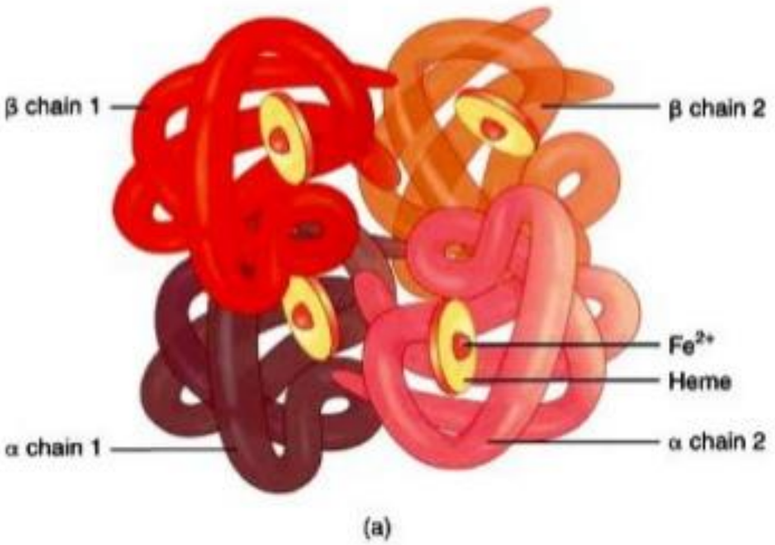
Red blood cells are:

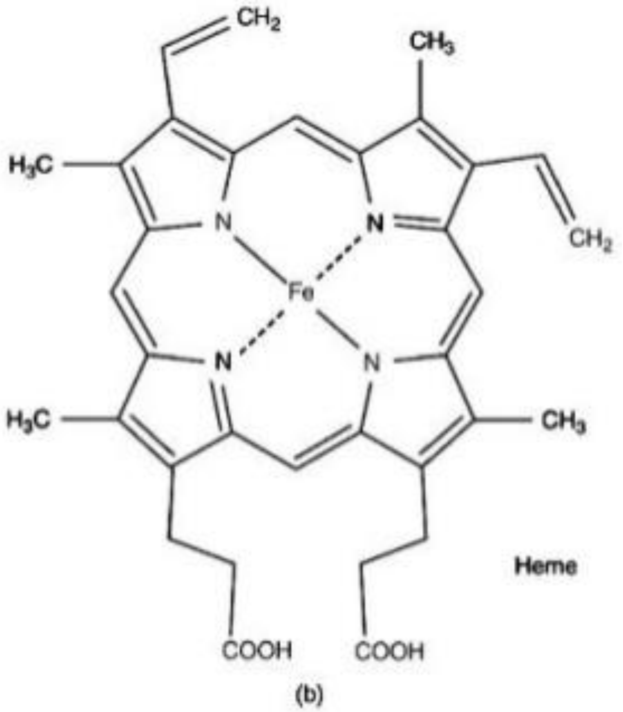
- Erythrocytes
- Biconcave discs
- Able to readily squeeze through capillaries
- Lack nuclei and mitochondria

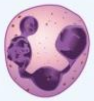
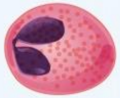
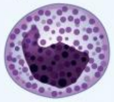
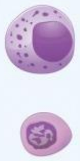
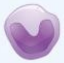




Haemoglobin





Leukocytes (white blood cells)		7000 (5000–10,000)	Obvious dark-staining nucleus	All function in body defenses	Exit capillaries and move into tissues; lifespan of usually a few hours or days
	Granulocytes including neutrophils, eosinophils, and basophils	4360 (1800–9950)	Abundant granules in cytoplasm; nucleus normally lobed	Nonspecific (innate) resistance to disease	Classified according to membrane-bound granules in cytoplasm
	Neutrophils 	4150 (1800–7300)	Nuclear lobes increase with age; pale lilac granules	Phagocytic; particularly effective against bacteria. Release cytotoxic chemicals from granules	Most common leukocyte; lifespan of minutes to days
	Eosinophils 	165 (0–700)	Nucleus generally two-lobed; bright red-orange granules	Phagocytic cells; particularly effective with antigen- antibody complexes. Release antihistamines. Increase in allergies and parasitic infections	Lifespan of minutes to days
	Basophils 	44 (0–150)	Nucleus generally two-lobed but difficult to see due to presence of heavy, dense, dark purple granules	Promotes inflammation	Least common leukocyte; lifespan unknown
	Agranulocytes including lymphocytes and monocytes	2640 (1700–4950)	Lack abundant granules in cytoplasm; have a simple-shaped nucleus that may be indented	Body defenses	Group consists of two major cell types from different lineages
	Lymphocytes 	2185 (1500–4000)	Spherical cells with a single often large nucleus occupying much of the cell's volume; stains purple; seen in large (natural killer cells) and small (B and T cells) variants	Primarily specific (adaptive) immunity: T cells directly attack other cells (cellular immunity); B cells release antibodies (humoral immunity); natural killer cells are similar to T cells but nonspecific	Initial cells originate in bone marrow, but secondary production occurs in lymphatic tissue; several distinct subtypes; memory cells form after exposure to a pathogen and rapidly increase responses to subsequent exposure; lifespan of many years
	Monocytes 	455 (200–950)	Largest leukocyte with an indented or horseshoe-shaped nucleus	Very effective phagocytic cells engulfing pathogens or worn out cells; also serve as antigen-presenting cells (APCs) for other components of the immune system	Produced in red bone marrow; referred to as macrophages after leaving circulation

MUSCULAR TISSUE

Origin:

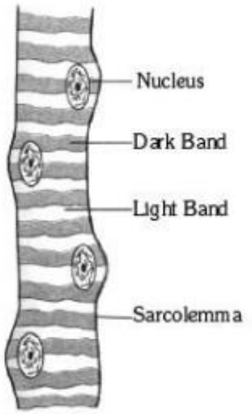
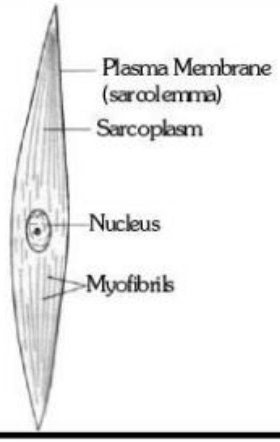
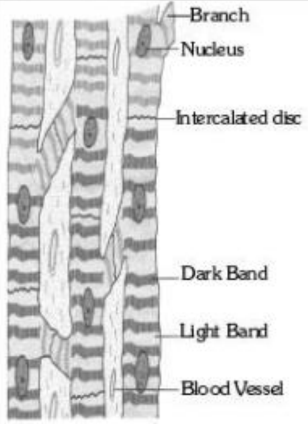
The muscle tissue arises from the embryonic **mesoderm**.

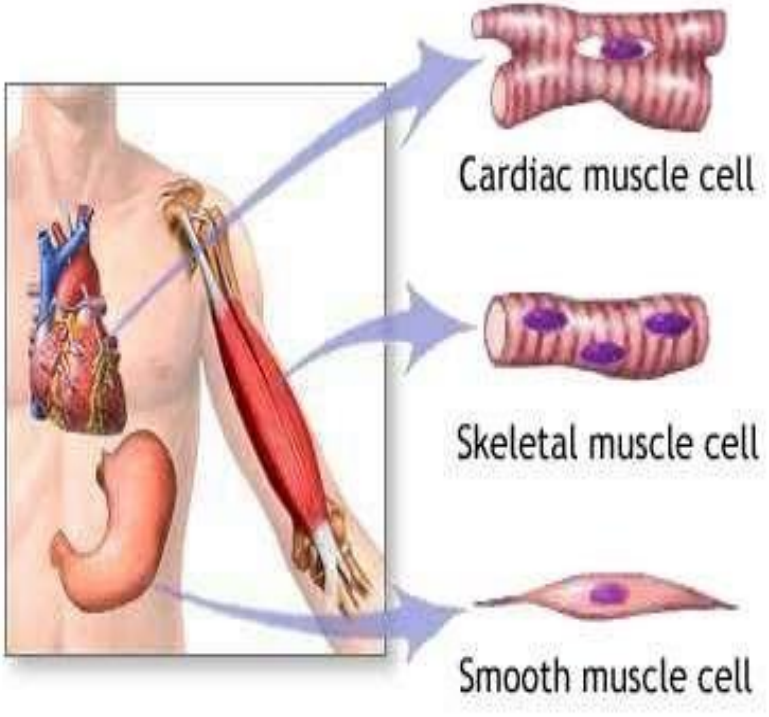
General Structure:

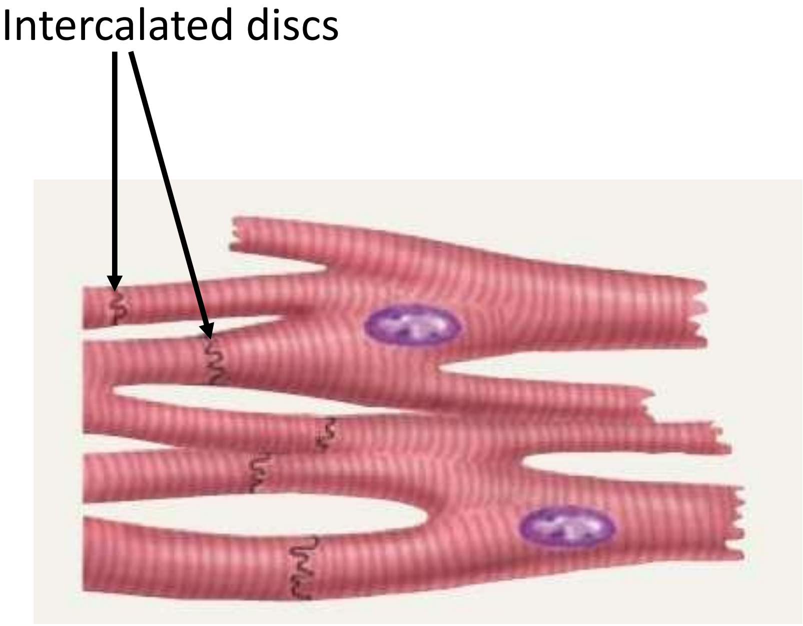
- Muscular **tissue** is made up of thin, elongated, contractile **muscle fibres (cells)**; hence it is also called *contractile tissue*.
- Muscle fibres are thin, elongated cells with one or many nuclei.
- The plasma membrane or the outer covering of a muscle fibre is called **sarcolemma**.
- The cytoplasm of a muscle fibre is called **sarcoplasm**. The sarcoplasm is largely occupied by longitudinal, parallel protein threads, called **myofibrils**, arranged along the axis of the fibre. These protein threads contain **myosin** and **actin**.
- The fibres have the ability to contract due to the presence of **myosin** and **actin**. Hence, they play an important role in locomotion and movement.
- The muscular tissue is innervated (supplied) and vascular.

Based on their structure, location and function, the muscles tissue is categorized into three types:

1. Striated or skeletal or voluntary muscles
2. Non-striated or smooth or involuntary muscles
3. Cardiac muscles

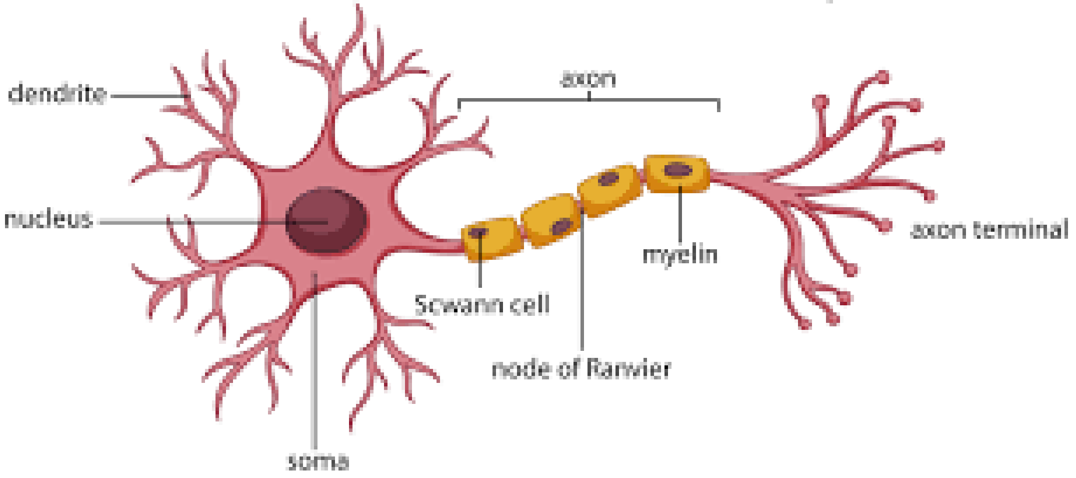
Striated muscle	Non-striated muscle	Cardiac muscle
	 Plasma Membrane (sarcolemma) Sarcoplasm Nucleus Myofibrils	 Branch Nucleus Intercalated disc Dark Band Light Band Blood Vessel

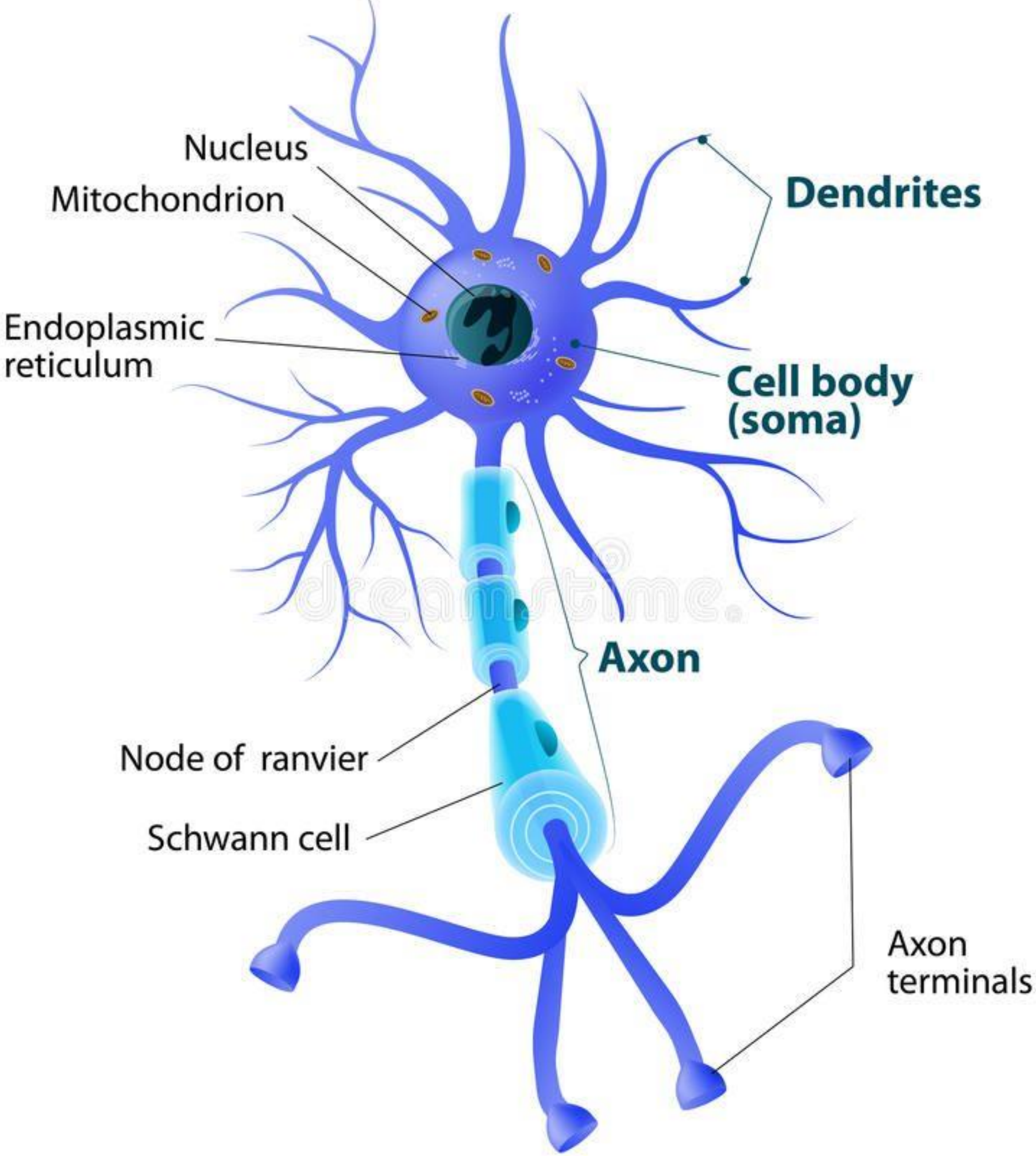




NERVOUS TISSUE

- The nervous tissue arises from the ***ectoderm*** of the embryo.
- Nervous tissue is composed of *nerve cells or* ***neurons*** and *supportive cells* called **neuroglia** or **glial cells**.
- Neurons possess two important basic properties: **excitability and conductivity**.
- Bundles of neurons + neuroglia = Nerve.
- In nerves, neurons are arranged end to end.
- Junction of 2 neurons – *Synapse.*
- Neurons conduct electro-chemical impulses ; electric within neuron, chemical at synapse.
- Dendrons (dendrites) receive impulse and axon transmits impulse.
- Nissl's granules are characteristic of neurons, confined to cell body, bundles of RER and ribosomes.




Nucleus
Mitochondrion
Endoplasmic reticulum
Dendrites
Cell body (soma)
Axon
Node of ranvier
Schwann cell
Axon terminals